Schäfter+Kirchhoff

Line Scan Cameras

from 512 to 22800 pixels, monochrome or color or TDi

Interfaces: Gigabit ETHERNET | GiGE VISION

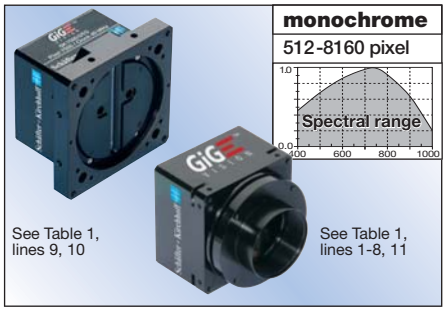
Schäfter+Kirchhoff offers two types of line scan camera with a Gigabit Ethernet interface. The hardware is technically identical and they differ only in their respective firmware.
V-series cameras are 100% GigE Vision compatible and programming is performed using the **GEN<i>CAM™** interface.
G-series cameras are not Vision compliant and their major strengths are in high performance, flexibility and additional functionality beyond the norm.

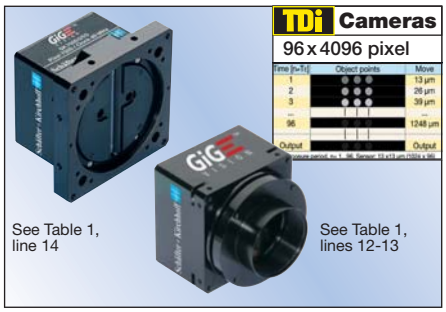
Gigabit ETHERNET

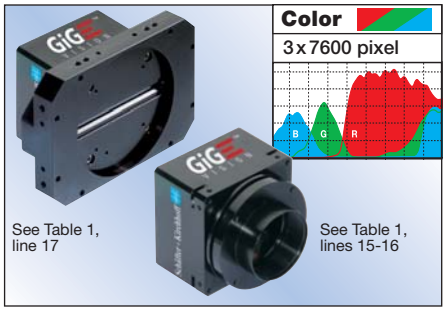
- special preprocessing algorithms can be implemented in the camera
- externally synchronizable for each line (LineSync), or for image (FrameSync)
- customer-specific IO signals in addition to the video signal
- SDK from **Schäfter+Kirchhoff** with the **SkLineScan** operating program, libraries and examples (**Sk91GigE-WIN**, see page 15)

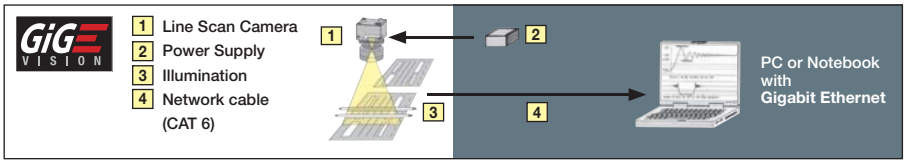
GiGE VISION

- compliant with the international standard for the industrial processing of image data based upon the Gigabit Ethernet protocol
- cameras are supported by any third party software that uses the **GEN<i>CAM™** software interface
- **Schäfter+Kirchhoff** provides the **SkGEVTool**, with its oscilloscope display of the signal, for adjustment of the camera (see page 17)









Features	Gigabit ETHERNET	GiGE VISION
Shading correction	X	X
Thresholding	X	-
Window function (ROI)	X	X
External synchronization	X	X
Extra I/O signals	X	-
User managed buffer queue	X	-
Data cable length	100 m	100 m
Windows	SK91GigE-WIN SDK	SkGEVTool-WIN Tool
LabVIEW	SK91GigE-LV VI Library	NI-IMAQdx
Linux	-	SKGEVTool-LX Tool

SK7500VTO-XL
SK7500GTO-XL (Casing CG5) with focus adapter FA26-S45, extension ring ZR-L..., adapter M39-45 and macro lens Apo-Rodagon D1x 4.0/75 mm for 1:1 depictions of the scanned object

SK2048VPD
SK2048GPD with mounting bracket SK5105 and photo lens SK1.4/50-40 (integrated focus/aperture adjustment)

SK1024VSD
SK1024GSD
with mounting bracket SK5105 and CCTV lens

Table 1

Interface		Line scan camera: Gigabit ETHERNET Order code	Line scan camera: GiGE VISION Order code	Pixels	Line frequency, max.	Video signal	Pixel size	Active length	Anti-Bloom	Integr. Ctrl.	Shading corr.	Threshold mode	Dynamic range (RMS)	Power supply	Camera casing	Lens thread
		Order code	Order code	1	2	3	4	5	6	7	8	9	10	11	12	13
Gigabit ETHERNET / GiGE VISION	1	SK512GSD	SK512VSD	512	53.50 kHz	8/12 Bit	14 x 14 µm	7.17 mm	x	x	x	x	1:2000	+5V, +15V	BG1	C-Mount
	2	SK1024GPD	SK1024VPD	1024	45.00 kHz	8/12 Bit	10 x 10 µm	10.24 mm	x	x	x	x	1:1500	+5V, +15V	BG1	C-Mount
	3	SK1024GSD	SK1024VSD	1024	28.00 kHz	8/12 Bit	14 x 14 µm	14.30 mm	x	x	x	x	1:2000	+5V, +15V	BG1	C-Mount
	4	SK2048GJR-L	SK2048VJR-L	2048	4.73 kHz	8/12 Bit	14 x 14 µm	28.70 mm	-	x	x	x	1: 625	+5V, +15V	BG3	M45x0.75
	5	SK2048GPD-L	SK2048VPD-L	2048	23.00 kHz	8/12 Bit	10 x 10 µm	20.50 mm	x	x	x	x	1:1500	+5V, +15V	BG3	M45x0.75
	6	SK2048GSD-L	SK2048VSD-L	2048	14.30 kHz	8/12 Bit	14 x 14 µm	28.70 mm	x	x	x	x	1:2000	+5V, +15V	BG3	M45x0.75
	7	SK4096GFD-L	SK4096VFD-L	4096	27.78 kHz	8/12 Bit	10 x 10 µm	41.00 mm	x	x	x	-	1:2000	+5V, +15V	BG3	M45x0.75
	8	SK5150GJR-L	SK5150VJR-L	5148	7.56 kHz	8/12 Bit	7 x 7 µm	36.00 mm	-	-	x	x	1: 500	+5V, +15V	BG3	M45x0.75
	9	SK7500GTF-XB	SK7500VTF-XB	7500	8.26 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	x	x	1:1000	+5V, +15V	EG5	M72x0.75
	10	SK7500GTO-XL	SK7500VTO-XL	7500	5.20 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	x	x	1: 750	+5V, +15V	CG5	M72x0.75
	11	SK8160GKO-LB	SK8160VKO-LB	8160	11.90 kHz	8/12 Bit	5 x 5 µm	40.80 mm	x	x	x	x	1:2500	+5V, +15V	BG3	M45x0.75
	12	SK1024GTDI-L	SK1024VTDI-L	96 x 1024	43.40 kHz	8/12 Bit	13 x 13 µm	13.30 mm	x	-	x	x	1:2500	+5V, +15V	BG3	M45x0.75
	13	SK2048GTDI-L	SK2048VTDI-L	96 x 2048	43.50 kHz	8/12 Bit	13 x 13 µm	26.60 mm	x	-	x	x	1:2500	+5V, +15V	BG3	M45x0.75
	14	SK4096GTDI-XL	SK4096VTDI-XL	96 x 4096	22.70 kHz	8/12 Bit	13 x 13 µm	53.20 mm	x	-	x	x	1:2500	+5V, +15V	CG5	M72x0.75
	15	SK6288GKOC-L	SK6288VKOC-L	3 x 2096	9.28 kHz	8/12 Bit	14 x 14 µm	29.30 mm	-	x	x	-	1:2500	+5V, +15V	BG3	M45x0.75
	16	SK12240GKOC-LB	SK12240VKOC-LB	3 x 4080	4.80 kHz	8/12 Bit	10 x 10 µm	40.80 mm	x	x	x	-	1:2500	+5V, +15V	BG3	M45x0.75
	17	SK22368GTOC-LA	SK22368VTOC-LA	3 x 7456	5.13 kHz	3*8 Bit	4.7 x 4.7 µm	35.04 mm	-	-	x	-	1:1000	+5V, +15V	BG3	M45x0.75
	18	SK22800GJRC-XC	SK22800VJRC-XC	3 x 7600	4.95 kHz	3*8 Bit	9.3 x 9.3 µm	70.87 mm	-	-	x	-	1:1000	+5V, +15V	FG7	M72x0.75

The camera casing, power supply and connections are identical for line scan cameras with either of the interfaces: GigE Vision™ or Gigabit Ethernet.

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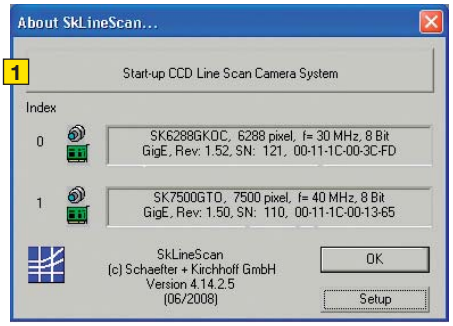
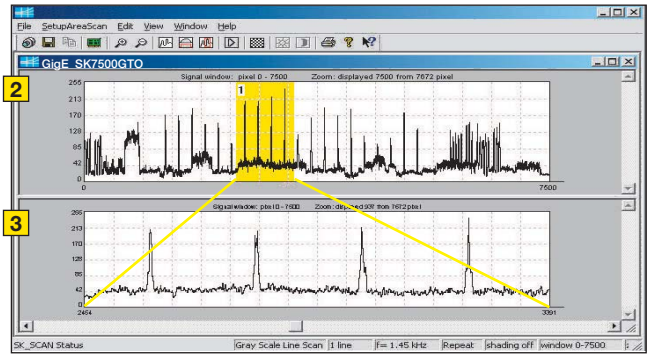
Gigabit ETHERNET — Software SK91GigE-WIN, SkLineScan Program



The **SK91GigE-WIN** software package includes everything needed for a rapid setup of the GigE camera, the configuration tool **SKGigEconfig**, as well as the software development kit (SDK) with DLLs and class libraries for development of application software. The Windows 7 (x64, x86) / Vista (x64, x86) and XP operating systems are supported.

The **SkLineScan®** program recognizes the connected line scan cameras automatically and organizes the camera IDs according to the increasing values of their individual MAC addresses 1 .

The oscilloscope display 2 of the line scan signal, with zoom function 3, is an important tool for aligning the optical system. Controls for integration time, gain and offset allow the online configuration of the camera.

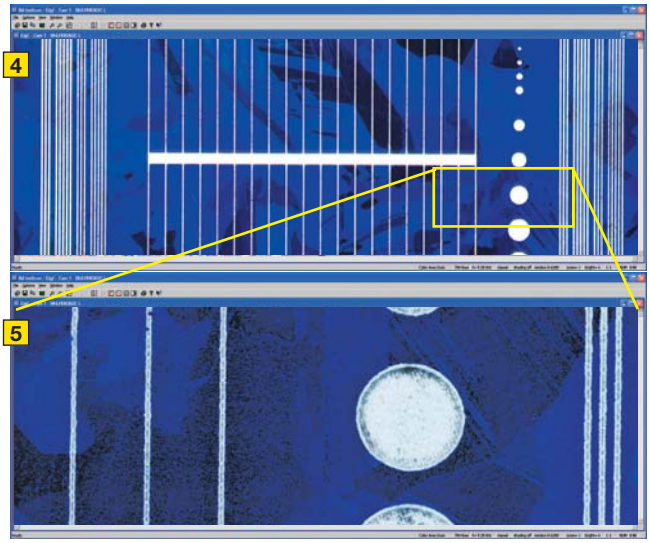


2-dimensional area scans can easily be performed using the **SkLineScan®** program 4. Simply specify the number of line scans to be integrated into the scan to produce a desired area scan.

The zoom function allows the magnification of interesting areas 5 and full or partial images can be stored as bitmaps.

For color line scan cameras, a white balance correction is necessary and the shading correction procedure described on this page provides this capability.

The various synchronization procedures allow images to be acquired either stepwise per line (**LineSync**) or per area (**FrameSync**) using an external trigger, according to the particular requirements of the customer or the image aquisition application.

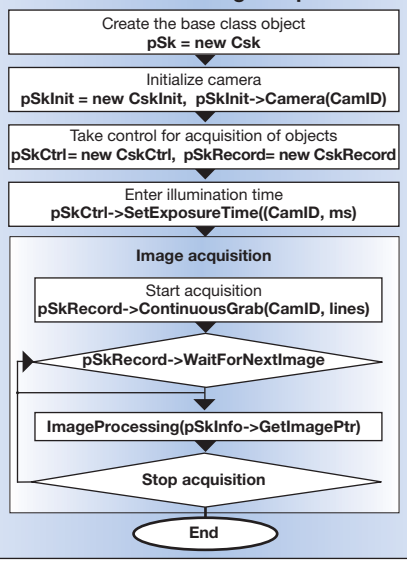


SDK for GigE line scan cameras

Csk	**– Base class**
struct sk_interface	Communication structure for the driver
CskInit: Csk	**– Initializing class**
::Camera	Initializing the camera
::AllocBuffer	Allocate memory in the user area
::FreeBuffer	Release memory
::SetUserBufferPtr	Set pointer to user buffer
CskCtrl: Csk	**– Control class**
::SetIntegrationTime	Set integration time (ms)
::SetLineFrequency	Set line frequency (kHz)
::SetSyncMode	Set synchronization mode
::SetGain	Set camera gain
::SetOffset	Set camera offset
CskRecord: Csk	**– Acquisition class**
::SingleLineScan	Get a single line scan
::AreaScan	Acquire a 2D scan
::ContinuousGrab	Start continuous grab
::GetImage	Get single image from a continuous grab
::StopContinuousGrab	Stop continuous grab
CskView: Csk	**– View class**
::LineScanView	Display a line scan signal
::AreaScanView	Display an area scan
CskInfo: Csk	**– class**
::GetCamType	Name of current camera
::GetPixWidth	Number of current camera pixels
::GetLineFrequency	Current line frequency in kHz
::GetUserBufferPtr	Pointer to data set in user memory

* Examples from the class library containing more than 60 ways to control a GigE line scan camera

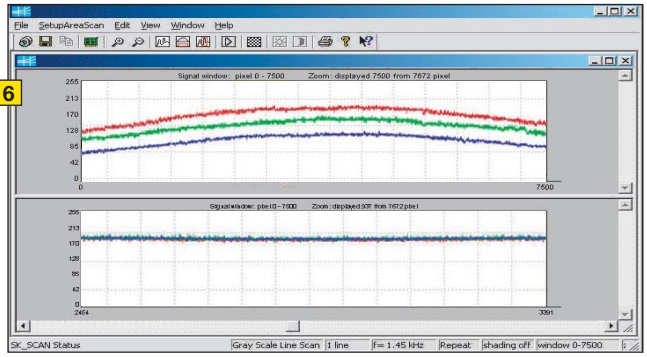
Flow of camera image acquisition



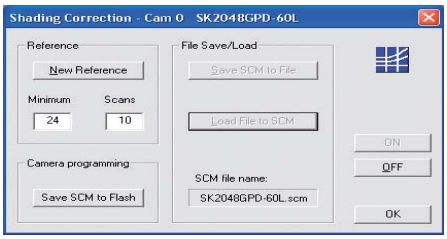
SK91GigE-WIN Order Code

Shading Correction with the SkLineScan program

Shading correction is a procedure used for compensating for the potential sources of variation in the signal, whether caused by lens vignetting or variations in pixel sensitivity or illumination. A reference signal for the shading correction is obtained by taking an image of a plain white surface, so that each individual pixel can be compensated for algorithmically to provide a maximum overall intensity, depending on the scale (e.g. 4095 for a 12-bit resolution), and producing an idealized flat signal.



The shading correction reference values are stored in the designated shading correction memory (SCM) in the camera for future use. The persistent writing of the SCM into the camera memory uses the **GEN<i>CAM** command **SkSaveScmToFlash** from the custom feature table. Shading correction for color line scan cameras uses the white balance method (see 6).



The dialog window for **Shading Correction** in the **SkLineScan** program.

New Reference: Acquisition of a new shading correction reference set and its storage in the SCM

Scans: Number of lines for the reference values to be determined

Minimum: Only the minimum pixel value is used for scaling

SaveSCM to Flash: Pesistent storage of the shading correction reference values in the flash memory of the camera

Save/Load: The shading correction reference values are written to or read from a file

1 Start-up and status window of the **SkLineScan** program
2 Oscilloscope display of a line scan signal
3 Zooming to a region of interest (yellow) in the line scan signal
4 Area Scan using the line scan camera SK6288GKOC-L
5 Zooming to a particular area of interest
6 Shading Correction function in the **SkLineScan** program

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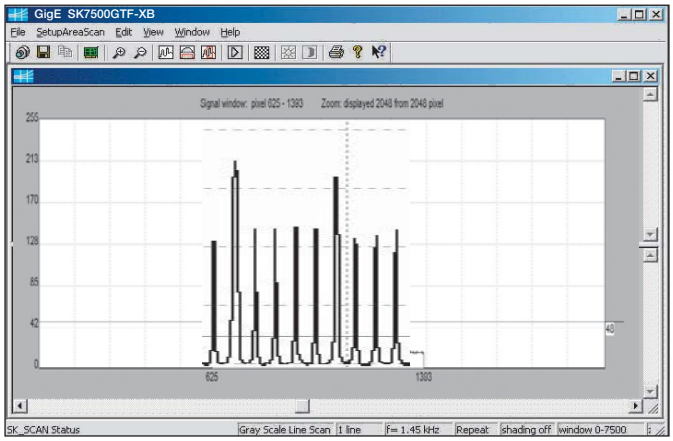
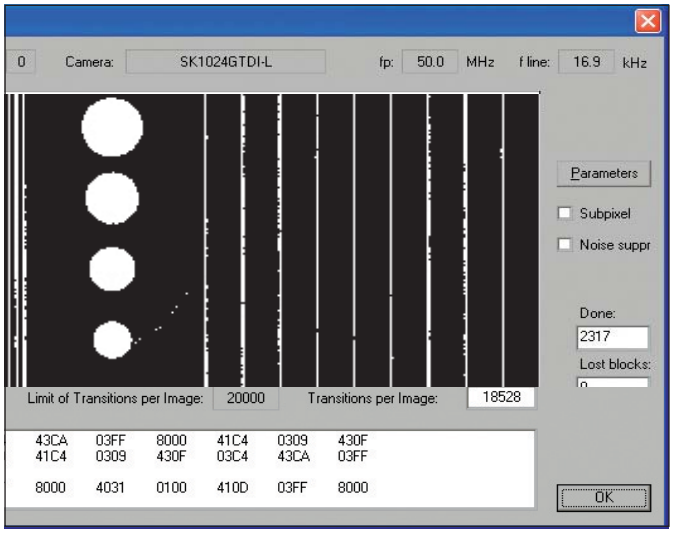
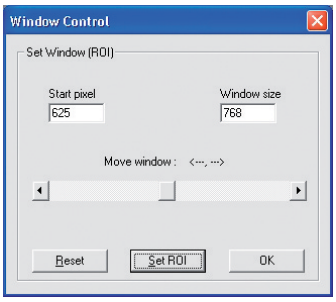
Gigabit ETHERNET Software SK91GigE-WIN





Example program for continuous Thresholding

Window Function (ROI)



Control dialog for setting a region of interest

The window function defines a freely programmable window (region of interest, ROI) on the line sensor. Only the pixel information within this window reaches the FIFO and, therefore, only these ranges are then illuminated. This window control function reduces the data volume and the data processing effort for both line and picture acquisitions.
The video data of the ROI is written left-bounded into the image buffer and the oscilloscope display in the **SkLineScan** program adjusts the ROI to the actual pixel address of the signal window. One restriction of the memory allocation is that the ROI length must be divisible by 8.

Thresholding

Thresholding is a special capability of cameras with a Gigabit Ethernet interface that offers an effective alternative to gray shade evalution and enumeration, assuming there is sufficient contrast available in the image. The development of thresholding is the successful outcome of an initiative to perform data reduction without information loss when monitoring changes in signal intensity. The thresholding process generates a binary signal, with data values below the threshold yielding 0 and those above yielding 1. Only the pixel addresses of the location and value (from high → low or low → high) of the threshold transition are transmitted with a line-end character (Runlength Encoding).

Thresholding is particularly suitable for measuring widths or edge positions, as the substantial complexities inherent in edge position determination have been reduced to simply masking the required pixel addresses.

Other thresholding features and possibilities include:

- **Noise suppression filtering**
- **Subpixel resolutions**

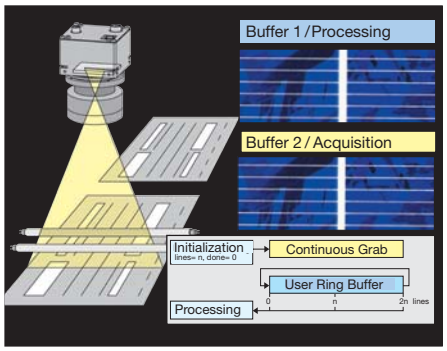
Data format:	16-bit integer without a starting character
Bit 0...13:	pixel address of the signal transition
Bit 14:	0 = transition from high → low 1 = transition from low → high
Bit 15:	1 = line end character

Gigabit ETHERNET Management of the GigE line scan camera memory by the user

The SDK in the **SK91GigE-WIN** software package provides library functions that allow the user to allocate memory areas for the image acquisition. The GigE line scan camera then writes directly into these predefined memory areas, obviating any copying of the data from one area to another. The writing of camera data into memory can be performed either in a cyclical manner or after all of the buffers have been filled. This latter method is particularly useful for a sequence of images, up to a maximum of 256 individual images.

The image sequence method allows the acquisition of extremely large images, circumventing the internal restriction of 64 MB and 16383 lines per image. The user defines the appropriate memory size in virtual memory for the desired size of image, which is then divided in up to 256 component parts. A sequence series is programmed by simply pointing to this buffer and the acquisition of the sequence images then results in the image data being collected up to the desired size.

Controlling continuous measurement processes using a GigE line scan camera



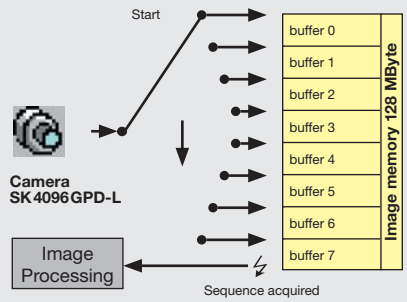
Special functions have been added to the SDK of the **SK91GigE-WIN** software from **Schäfter+Kirchhoff** that enable the efficient control and manipulation of continuous measurement applications

The ability to customize the memory allocation for the Gigabit Ethernet line scan cameras can be used for the continuous collection of the camera data into a User Buffer Queue. This speeds up operations as data must not be copied back and forth, freeing up the CPU for other activities, such as data evaluation or for controlling external devices. The writing of data into the User Buffer Queue is cyclical. Up to 256 buffer suballocations can be set according to the demands of the application. The minimum permitted size is exactly one line scan.

The data in a previously filled buffer can be manipulated or evaluated while the camera is writing data into the next buffer. The user receives an event signal and the address of the buffer in the queue that was written to last. For the successful continuous evaluation of camera data in the two buffers, without loss of data, the evaluation of the first buffer must be completed after the illumination of *n* lines, at the latest.

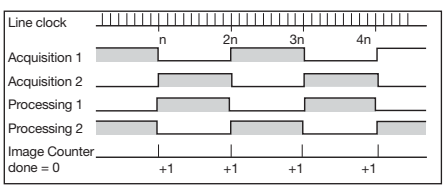
The sequential method of acquisition of large images with a GigE line scan camera

image dimension:	4096 x 32768 Pixel
image size:	128 MByte
number of buffers:	8
buffer size :	16 MByte



When more than two buffers are allocated and there is a time delay caused by the manipulation of data from one buffer then the time delay can be recovered by the rapid utilization of the data in the next or subsequent buffers.

Thus, there are effectively no time limits or restrictions when performing continuous acquisition and data manipulation tasks.



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Software

The V series of line scan cameras are 100% compatible with the **GigE Vision™** and **GEN<i>CAM™** standards and can be controlled using any program of choice that supports the **GEN<i>CAM** standard.*
The **SkGEVTool**, for either Windows** or Linux, is provided by **Schäfter+Kirchhoff** for the commissioning and initial parameterization of the camera and is available for downloading.

SkGEVTool for Windows and Linux

The **SkGEVTool** was specially developed for controlling the line scan cameras. The oscilloscope display of the signal provides an intuitive depiction for adjusting the illumination time, amplification, lens shutter, focus and orientation of the line scan camera.

The **SkGEVTool** can use either of the Pleora drivers eBus Optimal or eBus Universal, which can be downloaded from *www.pleora.com* after registering online.

1 Oscilloscope display of the line signal using the zoom function. Any alterations to the illumination time or amplification of the line scan camera are immediately displayed.

2 Select **Area Scan** to perform a 2-dimensional scan of an area. The number of lines per image to be scanned is selected from the Device Feature List under **Height** in the category **Image-SizeControl**.

* e.g. Common Vision Blox from STEMMER, MIL from Matrox, NIMAX National INstruments, HALCON from IDS, etc.
** Operating systems: Windows 7 / Vista (32/64 bit) and XP

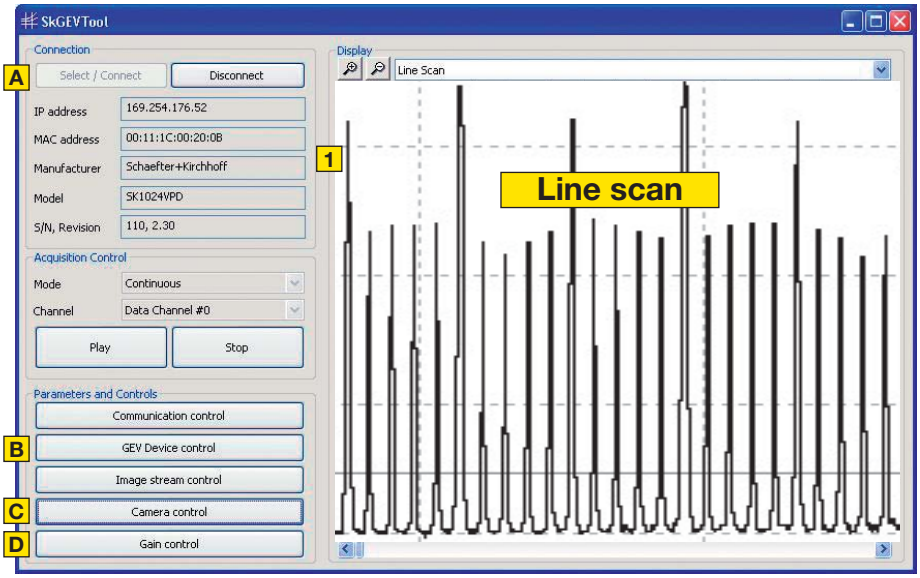
Device Feature Table (selection)

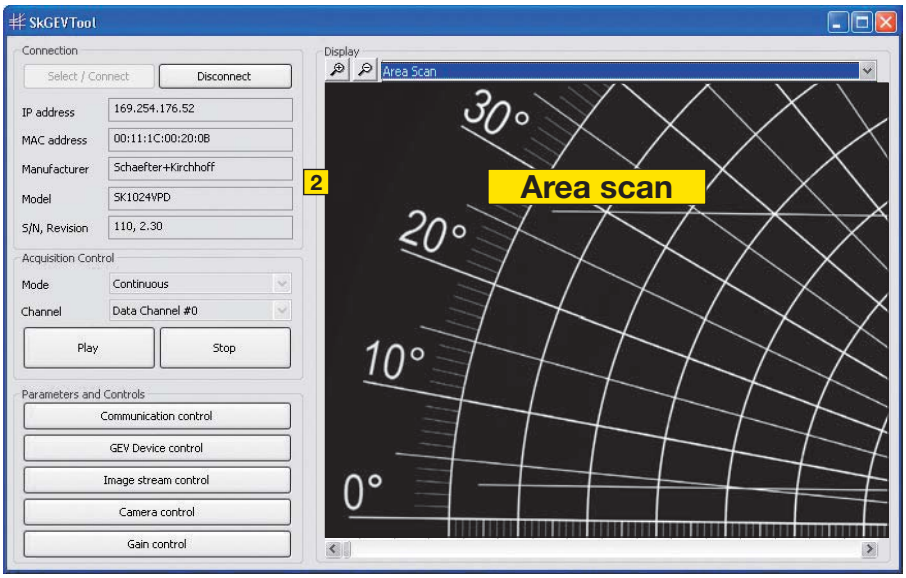
GEV Device Control — Visibility: Beginner

DeviceInformation	
DeviceVendorName	Schaefter+Kirchhoff
DeviceModelName	SK1024VPD
DeviceManufacturerInfo	Hamburg (00080602)
DeviceVersion	Version 1.0 (02.01.12)
DeviceID	S/N 110
DeviceUserID	
DeviceScanType	Linescan
ImageSizeControl	
SensorWidth	1024
SensorHeight	1
AnalogControls	
GainSelector	Tap1
BlackLevelSelector	All
GainRaw	128
GainAbs	6.0206 dB
BlackLevelRaw	4
AcquisitionAndTriggerControls	
AcquisitionLineRateAbs	12500 Hz
TriggerSelector	FreeRun
ExposureTimeRaw	80
AcquisitionFrameCount	1
ExposureTimeAbs	0.08 ms

AcquisitionLineRateAbs	12500 Hz
TriggerSelector	FreeRun
ExposureTimeRaw	LineStart / ExposureStart / ExposureActive / FreeRun
AcquisitionFrameCount	
ExposureTimeAbs	

A description of the trigger mode is provided on page 18





A Start with **Select/Connect**

B **GEV Device Control** reveals all camera features in the **GEN<i>CAM** table

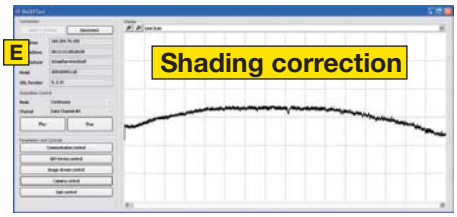
C **Camera control** enables the selection of illumination time and trigger mode

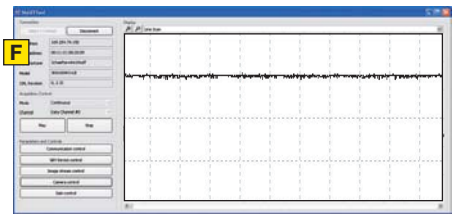
D **Gain control** adjusts the gain and offset

Shading Correction with the SkGEVTool

Shading correction is a procedure used for compensating for the potential sources of variation in the signal, whether caused by lens vignetting or variations in pixel sensitivity or illumination. A reference signal for the shading correction is obtained by taking an image of a plain white surface, so that each individual pixel can be compensated for algorithmically to provide a maximum overall intensity, depending on the scale (e.g. 4095 for a 12-bit resolution), and producing an idealized flat signal.
The shading correction reference values are stored in the designated shading correction memory (SCM) in the camera for future use. The permanent writing of the SCM in the camera uses the command **SkSaveScmToFlash** from the **GEN<i>CAM** custom features.
When shading correction is active then all images recorded by the camera are corrected by the content of the SCM and a fully compensated signal is produced.

SkShadCorrReference	SkShadCorrReference
SkSaveScmToFlash	{Command}





E A line signal from a homogeneous white surface reveals the typical signal loss at the extremities through lens vignetting

F A line signal after shading correction and reduction of illumination time

The camera always starts with the last-used shading correction status as default. If shading correction was deselected when the camera was switched off then the camera starts without shading correction using an unscaled line signal.

Gigabit ETHERNET GiGE VISION — Synchronization modes

LINE SYNC Modes

FreeRun (mode 0): The next scan is started automatically on completion of the previous line scan. The camera works in free run mode with the programmed exposure time.

LineStart (mode 1): The line scan exposed at the time of the external trigger is read out. The start and duration of exposure are controlled internally by the camera. The trigger frequency does not affect the exposure time.

ExposureStart (mode 4): A new line exposure is started exactly at the time of triggering (falling of a TTL signal trailing edge). Programmed exposure times are unaffected by, although must be longer than, the trigger frequency.

ExposureActive (mode 5): The external trigger determines the start and duration of illumination, which also equals the total exposure time.

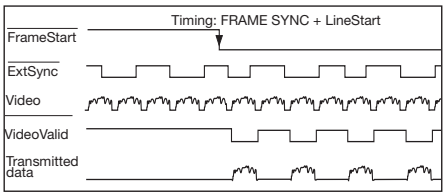
Sync divider: The external trigger frequency is divided by a programmed integer. Only every *n*-th line is recorded.

FRAME SYNC Mode

As well as a line synchronization mode, the GigE line scan cameras also have external frame synchronization (**FrameSync**) for the synchronized acquisition of 2D scans.

The individual lines of the image can be synchronized internally or externally. The camera suppresses the data transfer until the falling edge of a TTL signal occurs at **FrameStart** input (e.g. triggered by breaking a light beam). Only then is **VideoValid** set to active and the subsequent camera data can then be transferred via GigE to the PC.

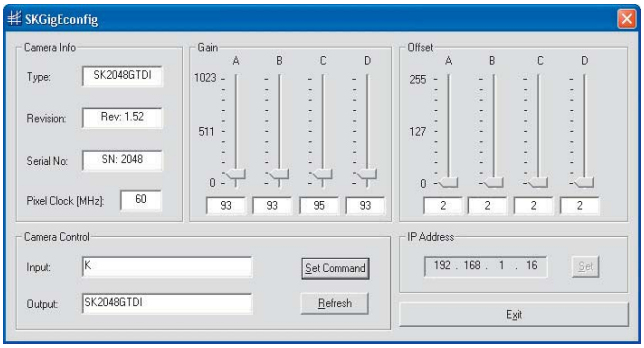
In the **FrameActive** mode, data acquisition is terminated by the rising edge of a TTL signal, before the image has been completely acquired, allowing the precise measurement of objects of varying length.



Selection of camera commands

Operation	Description
Gnnnn<CR>	Set Gain Chan1 (Red) 0-24 dB
Bnnnn<CR>	Set Gain Chan2 (Green) 0-24 dB
Hnnnn<CR>	Set Gain Chan3 (Blue) 0-24 dB
Ommm<CR>	Set Offset Chan1 (Red)
Pmmm<CR>	Set Offset Chan2 (Green)
Qmmm<CR>	Set Offset Chan3 (Blue)
F1<CR>	Output Format: Thresholding
F8<CR>	Output Format: 8 bit data
F12<CR>	Output Format: 12 bit data
C30<CR>	Camera Clock: 30 MHz
C60<CR>	Camera Clock: 60 MHz
T0<CR>	Test pattern off / SCM off
T1<CR>	Test pattern on
T2<CR>	Shading Correction on
T3<CR>	Auto Shading Correction, SCM on
T4<CR>	Copy Flash Memory to SCM
T5<CR>	Copy SCM to Flash Memory
M0<CR>	Free Run
M1<CR>	Trigger **LineStart** (Mode 1)
M2<CR>	Free Run with maximum line rate
M4<CR>	Trigger **ExposureStart** (Mode 4)
M5<CR>	Trigger **ExposureActive** (Mode 5)
Lmmm<CR>	Set threshold level
K<CR>	returns SK type number
R<CR>	returns Revision number
S<CR>	returns Serial number
I4<CR>	returns Camera Clock Low Freq.
I5<CR>	returns Camera Clock High Freq.
range of values:	
nnnn=	0...1023, mmm= 0...255

Configuration program SkGigEconfig

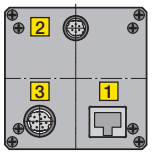


The config program **SkGigEconfig** uses the camera commands to adjust the GigE line scan camera parameters, such as gain, offset or pixel frequency.

Current parameters, as well as specific product information, can also be read from the camera.

The parameter settings are stored in the non-volatile flash memory of the camera and so are available for subsequent use and a rapid start-up, even after a complete shut down or loss of power.

Camera back view



1 Data:
RJ45 connector for Gigabit Ethernet cable specification CAT6

2 Power
Hirose Series 10A, male 6-pin, +5V, 700mA +15V, 350mA

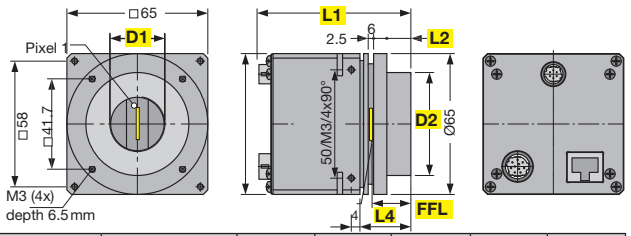
Pin	Signal	Pin	Signal
1	+15V	4	+5V
2	+15V	5	GND
3	+5V	6	GND

3 I/O-Connector
Hirose Series 10A, male 12-pin

Pin	Signal
1	GND
8	FrameSync
10	LineSync

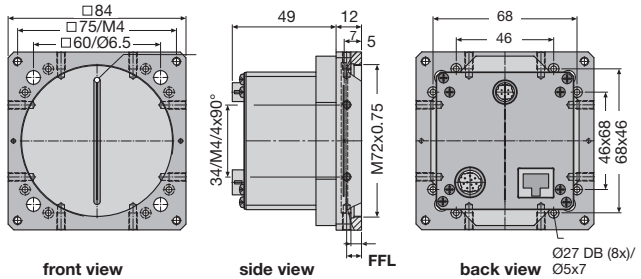
Dimensions

BG...
Lens mount: D1
Seat for bracket: D2
Flange focal length: FFL



Casing	D1 (Lens mount)	L1 (mm)	L2 (mm)	D2 (mm)	FFL (mm)	L4 (mm)
BG1	C-Mount	71.10	11.10	42.00	17.54	23.50
BG3	M45x0.75	72.40	12.70	47.50	19.50	25.10

CG5 Lens mount: M75x0.75
Flange focal length: FFL = 8mm



CG5 EG5 FG7 see Line Scan Camera Family XL/XB/XC, p. 36

Data/Control cable

CAT6 cable for line scan cameras with GigE interface

Shielded CAT6 patch cable, halogen-free, both ends with RJ45 connectors for Gigabit Ethernet

CAT6.3 Order Code
3 = 3m cable length (standard)
5 = 5m
x = length of choice (max.=100m)

Cable for external synchronization

External synchronization cable for line scan cameras with GigE interface

BNC coaxial cable with Hirose connector HR10A (female 12-pin)

SK9024.3 Order Code
3 = 3m cable length
5 = 5m (standard)
x = length of choice

External power — Power cable

Power supply cable SK9015... for line scan cameras with GigE interface

Shielded cable with Lumberg SV60 (male 6-pin) and Hirose HR10A (female 6-pin) connectors

SK9015.1.5-MF Order Code
MF = connector (male/female)
1.5 = 1.5m length
0.2 = 0.2m length

CAB0515.10 Extension cable for SK9015.0.2-MF, 10m

External power — Power supply

Power Supply PS051515 Order Code

Input:
- 100–240V AC
- 0.8A
- 50/60 Hz

Connector IEC 320 (3-pin)

Output:
- 5V DC/2.5A
- 15V DC/0.5A
- -15V DC/0.3A

Connector Lumberg KV60 (female 6-pin)

Software

Software SK91GigE-WIN Order Code

SkLineScan
Control program

SDK
with DLLs and C++ class library

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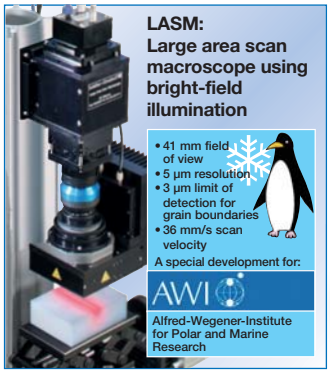
Line Scan Cameras

Some Examples from Research, Analytical and Quality Control

Interfaces: Gigabit ETHERNET · GiGE VISION™

Particle size and stratigraphy scanners in polar research

For details: see catalog pages 52–53



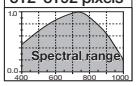
LASM: Large area scan macroscope using bright-field illumination

- 41 mm field of view
- 5 µm resolution
- 3 µm limit of detection for grain boundaries
- 36 mm/s scan velocity

A special development for:

AWI Alfred-Wegener-Institute for Polar and Marine Research

B/W cameras
512–8192 pixels



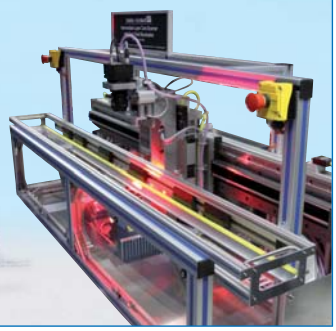
The collection of ice cores from the Greenland ice sheet, under the auspices of the (NEEM) North Greenland Eemian Ice Drilling project, was successfully completed in July 2010, after 3 years, when the drill-head hit bedrock. The ice cores from depths of up to 2.5 km provide a record of the past climate covering more than 120 000 years.

Scan of an ice core obtained from Antarctica at a depth of 60 m. The light granular structure and dark gas bubbles are clearly discernable.

The LASM scanner (left) was specially developed for documenting the fine structure of the ice cores and to determine the sizes of the ice granules and enclosed bubbles. The ILCS scanner (right) was developed for documenting the stratigraphy and dating of the ice cores. All of the mechanical, electronic and optical components were specially developed for use in the NEEM camp at temperatures down to -40°C.

Transportation to the Neem Camp

ILCS: Stratigraphy scanner using dark-field illumination



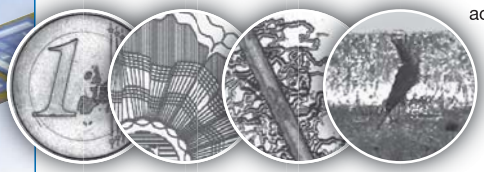
Line scan camera with integrated bright-field illumination

For details: see catalog pages 50, 56

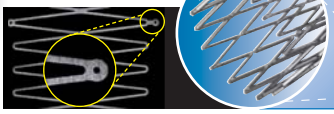
Automated surface and texture inspection of flat and rotating objects

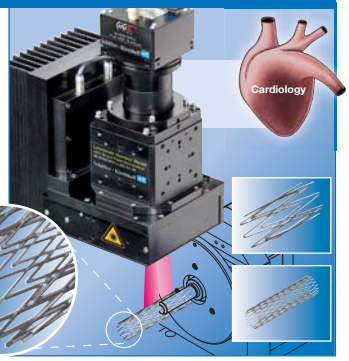
A novel development in automated surface inspection and analysis:
The application of increasingly sophisticated illumination techniques for the enhancement of specific object features is routine in microscopy.

High-contrast image acquisition of structured objects: making the invisible visible. Illumination and image acquisition techniques that exploit the object properties emphasize the features of real interest.



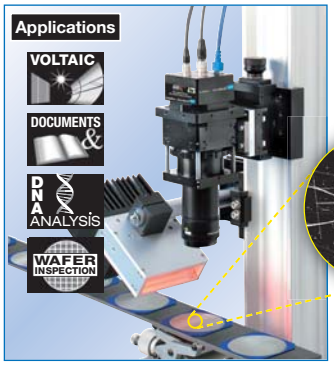
Imprint testing · Microembossing · Paint damage · Crack detection



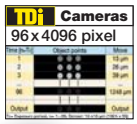


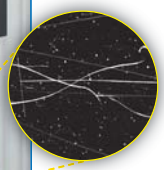
Dark-field illumination with a TDI line scan camera Wafer inspection

For details: see catalog pages 30–31



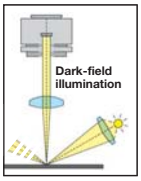
TDI Cameras
96 x 4096 pixel





For the detection of reflecting scratches and particles down to the submicron level.

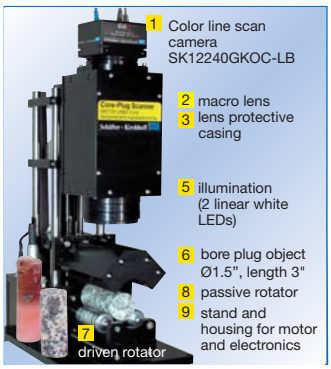
In industrial image processing, dark-field illumination is particularly useful for the examination of highly reflecting surfaces. The light beam is directed at the surface of the test object at a low angle of incidence, so that the light is undetected by the camera when reflected from a perfect surface. With an immaculate surface, a scanned object appears totally dark. When there are surface irregularities caused by some damage, such as a scratch or a crack, or contamination, such as dust, lint or grease, then a small part of the incident light is scattered diffusely, captured by the lens and directed onto the sensor. The tiniest of irregularities are observed as light areas on a dark background. The dark-field illumination of a reflective surface produces quite faint images. With conventional line scan cameras, longer integration times have to be used in comparison with directed bright-field illumination or for image acquisition from a diffusely reflecting object. Such low signal amplitudes mean only low line frequencies and scan velocities are possible. The highly amplified sensitivity of TDI line scan cameras make them particularly suitable for dark-field illumination, allowing much higher scan and measurement velocities to be achieved than are obtainable with conventional technology.



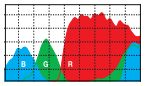
Application fields:
Surface examination of highly reflective materials, such as chips, wafers or mirrored surfaces.
Highlighting of contours, scratches, cracks, dust particles and dirt.

Plug Scanner SK-4080-GigE Color… Gold, Diamond and Oil Sniffer

For details: see catalog page 35


1 Color line scan camera SK12240GKOC-LB
2 macro lens
3 lens protective casing
5 illumination (2 linear white LEDs)
6 bore plug object Ø1.5", length 3"
8 passive rotator
9 stand and housing for motor and electronics
7 driven rotator

Color

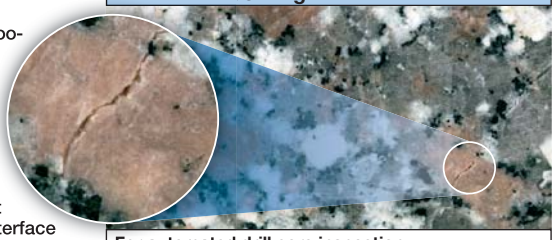


The bore plug scanner SK-4080-GigE Color was specially developed as a fully mobile surface-scanning macroscope by Schäfter+Kirchhoff for the investigation of smooth and cylindrical objects, such as ice bore plugs.

Features:

- Rapid and precise exchange of test objects by using two rotating supports
- Simple adjustment of focus for objects with different diameters
- A surface scan by simply pressing a switch or a mouse button
- Automatic white balance
- One-click zooming for 1:1 depictions
- Printing and saving of total or zoomed sections
- The Gigabit Ethernet interface makes the placement of the scanner highly flexible, so that it can be used almost anywhere

One-click zooming



For automated drill core inspection:
the color line scan camera SK12240GKOC-LB, 3 x 4080 pixel (RGB)
- Optical resolution of 1360 dpi
- For object diameters of 1"– 2" up to a length of 75 mm

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Line Scan Cameras

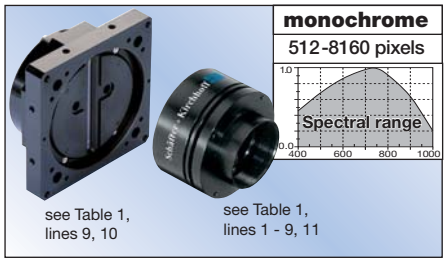
from 512 to 8160 pixels, monochrome, color or TDi

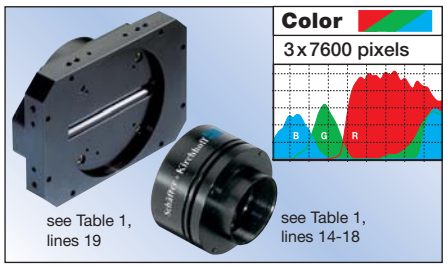
Interfaces: USB 3.0

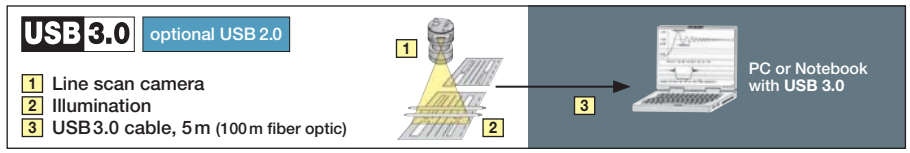
optional USB 2.0

Line scan cameras with a USB interface are particularly suitable for mobile applications or when it is necessary for a line scan camera to be used with a number of different PCs.
Being hot-pluggable, they can be connected to or detached from a notebook or PC without powering down. A supplementary Hirose connector can be used to provide power to the line scan camera as well as a trigger signal for exposure synchronization.
The USB 3.0 cable is plugged into the camera and fastened in place using an industry-standard securing screw whereas the USB 2.0 cable is permanently attached.

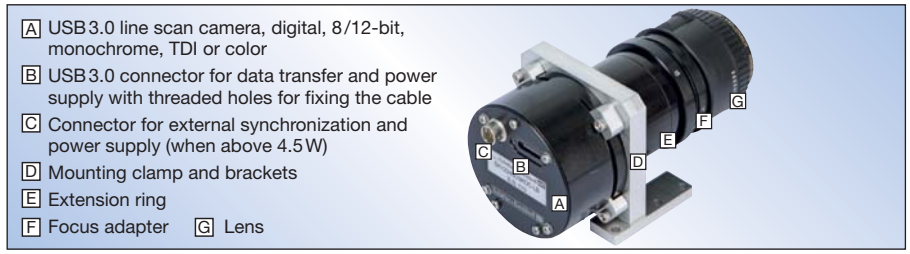
- High performance cameras for industry and lab
- Securely attached connectors, robust casings
- Frame grabber board is not needed
- USB 3.0 SuperSpeed enables the use of sensors at their maximum line frequencies
- Downwards compatible with USB 2.0







Features	
Line frequency	max. 83 kHz
Shading correction with permanently stored profiles	X
External synchronization	X
Status LED for power-on (red) and firmware loaded (green)	X
Extra I/O signals	X
Data cable length (default)	5 m
Extended cable length when using fiber optic cables	100 m
Windows	SK91USB3-WIN SDK
LabVIEW	SK91USB3-LV VI Library


A USB 3.0 line scan camera, digital, 8/12-bit, monochrome, TDI or color
B USB 3.0 connector for data transfer and power supply with threaded holes for fixing the cable
C Connector for external synchronization and power supply (when above 4.5 W)
D Mounting clamp and brackets
E Extension ring
F Focus adapter
G Lens

SK5148U3JR-L
with mounting bracket SK5105, focus adapter FA16-45 and scanning lens Apo-Rodagon N 4.0/80

SK2048U3SD
with mounting bracket SK5105, lens SK1.4/50-40 (with integrated focus and aperture adjustment)

SK7500U3TO-XL
with focus adapter FA26-S45, extension ring ZR-L.., adapter M39-45 and macro lens Apo-Rodagon D1x2.5/75 mm for 1:1 reproduction of images

Table 1

Interface		Line scan camera	Pixels	Pixel frequency, max.	Line frequency, max.	Video signal	Pixel size	Active length	Anti-Bloom	Integr. Ctrl.	Dynamic range (RMS)	Power supply	Camera casing	Lens thread
		Order code	1	2	3	4	5	6	7	8	9	10	11	12
USB 3.0	1	SK512U3SD	512	30 MHz	53.5 kHz	8/12 Bit	14 x 14 µm	7.17 mm	x	x	1:2000	USB (400 mA)	AT1	C-Mount
	2	SK1024U3PD	1024	60 MHz	52.6 kHz	8/12 Bit	10 x 10 µm	10.24 mm	x	x	1:2000	USB (550 mA)	AT1	C-Mount
	3	SK1024U3SD	1024	30 MHz	28.0 kHz	8/12 Bit	14 x 14 µm	14.30 mm	x	x	1:2000	USB (400 mA)	AT1	C-Mount
	4	SK2048U3JR	2048	10 MHz	4.73 kHz	8/12 Bit	14 x 14 µm	28.70 mm	-	x	1:1000	USB (350 mA)	AT2	M40x0.75
	5	SK2048U3PD	2048	60 MHz	27.78 kHz	8/12 Bit	10 x 10 µm	20.50 mm	x	x	1:2500	USB (550 mA)	AT2	M40x0.75
	6	SK2048U3SD	2048	30 MHz	14.3 kHz	8/12 Bit	14 x 14 µm	28.70 mm	x	x	1:2000	USB (450 mA)	AT2	M40x0.75
	7	SK4096U3PD-L	4096	50 MHz	11.9 kHz	8/12 Bit	10 x 10 µm	41.00 mm	x	x	1:2500	USB (700 mA)	AT3	M45x0.75
	8	SK5150U3JR	5148	40 MHz	7.56 kHz	8/12 Bit	7 x 7 µm	36.00 mm	-	-	1:1000	USB (550 mA)	AT2	M40x0.75
	9	SK7500U3TF-XB	7500	80 MHz	10.1 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	1:1000	+5V, +15V	ET5	M72x0.75
	10	SK7500U3TO-XL	7500	40 MHz	5.20 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	1:1000	USB (600 mA)	CT5	M72x0.75
	11	SK8160U3KO-LB	8160	100 MHz	11.90 kHz	8/12 Bit	5 x 5 µm	40.80 mm	x	x	1:2000	+5V, +15V	AT3	M45x0.75
	12	SK1024U3TDI	96 x 1024	50 MHz	43.4 kHz	8/12 Bit	13 x 13 µm	13.30 mm	x	-	1:2500	+5V, +15V	AT2	M40x0.75
	13	SK2048U3TDI	96 x 2048	100 MHz	43.40 kHz	8/12 Bit	13 x 13 µm	26.60 mm	x	-	1:2500	+5V, +15V	AT2	M40x0.75
	14	SK6288U3KOC	3 x 2096	60 MHz	9.28 kHz	8/12 Bit	14 x 14 µm	29.30 mm	-	x	1:2500	USB (600 mA)	AT2	M40x0.75
	15	SK8100U3JRC	3 x 2700	24 MHz	2.86 kHz	8/12 Bit	8 x 8 µm	21.60 mm	-	x	1:2000	USB (500 mA)	AT2	M40x0.75
	16	SK10944U3JRC	3 x 3648	24 MHz	2.14 kHz	8/12 Bit	8 x 8 µm	29.20 mm	-	x	1:2000	USB (500 mA)	AT2	M40x0.75
	17	SK12240U3KOC-LB	3 x 4080	60 MHz	4.80 kHz	8/12 Bit	10 x 10 µm	40.80 mm	x	x	1:2500	+5V, +15V	AT3	M45x0.75
	18	SK16080U3JRC-L	3 x 5360	24 MHz	1.47 kHz	8/12 Bit	8 x 8 µm	42.90 mm	-	x	1:2000	USB (500 mA)	AT3	M45x0.75
	19	SK22500U3NEC-XC	3 x 7504	200 MHz	8.53 kHz	3 * 8 Bit	9.3 x 9.3 µm	69.97 mm	-	-	1:1000	+5V, +15V	FT7	M72x0.75

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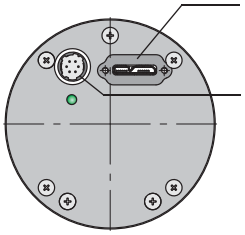
USB 3.0 Line Scan Camera Connectors



Data transfer and power supply (up to 4.5 W):
USB 3.0 connector, socket type micro B

Trigger signal and power supply (above 4.5 W):
Socket: Hirose series HR10A, male 6-pin

Pin	Signal	Pin	Signal
1	Line Sync B	4	+5 V *
2	+15 V *	5	Line Sync A
3	Frame Sync	6	GND

Rear view of the USB 3.0 line scan camera with a USB 3.0 socket for external synchronization control and for supply of power to those cameras consuming more than 4.5 W. The USB 3.0 type µB connectors are provided with a secure locking screw.

Synchronization modes for USB 3.0 Line Scan Cameras

LINE SYNC Modes

FreeRun: The next exposure of a line scan is started automatically on completion of the previous line scan.

LineStart: The line scan exposed at the time of the external trigger is read out. The start and duration of exposure are controlled internally by the camera. The trigger frequency does not affect the exposure time.

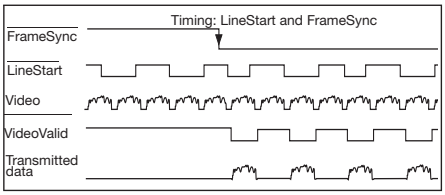
ExposureStart: A new line exposure is started exactly at the time of triggering. Programmed exposure times are unaffected by, although must be longer than the trigger period.

ExposureActive: The external trigger signal determines the start and end of exposure, which is defined by the trigger period.

SyncDivider: The external trigger frequency is divided by a programmed integer. Only every *n*-th line is recorded.

FRAME SYNC

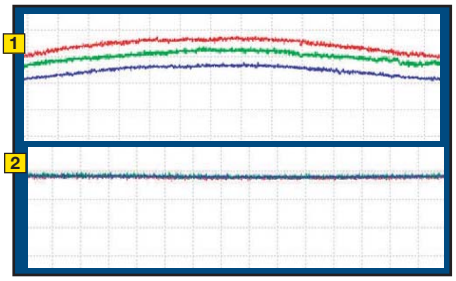
Additional to the LineSync modes, the USB 3.0 line scan cameras have the external frame synchronization (FrameSync) for triggering the acquisition of 2-dimensional images. The individual lines can be synchronized internally or externally. The camera suppresses the data transfer until the falling edge of a TTL signal occurs at the **FrameStart** input (e.g. triggered by breaking a light beam). Only then is **VideoValid** is active and the subsequent camera data can be transfered to the PC.



Shading Correction profile for permanent storage in camera memory

Shading Correction is used to compensate for non-uniform illumination, lens vignetting and/or any differences in pixel sensitivity. The image from a white homogeneous background is used as a reference to correct each pixel of the sensor with an individual factor, scaled up to a adjustable level. The result is a homogeneous image over the complete area when a white object is scanned. The correction profile can be stored permanently in the Shading Correction Memory (SCM) of the camera for immediate use when the camera is reactivated at the next start.
With color line scan cameras, shading correction can also be used as a white balance.

1 The line scan signal of a triple line color camera with different intensities for R, G, B.
2 After shading correction, the flat signal confirms the alignment of RGB intensities, here scaled to the maximum intensity of the raw signal.



USB 2.0 Compatibility

When the USB 3.0 camera is connected to a USB 2.0 socket of a PC then the operating system warns the user that the equipment is capable of higher speeds with a faster socket. The camera is automatically reduced to the USB 2.0 Hi-Speed mode, which can restrict the maximum line frequency capabilities of the higher specification line scan camera models.

In all other respects, the USB 3.0 cameras have full functionality under USB 2.0.
Sometimes the designation of a socket as USB 2.0 is because the connecting USB cable is incapable of USB 3.0 SuperSpeed rates.
Cameras with power requirements greater than 500 mA need an extra power source when attached to a single USB 2.0 socket.

Type A USB connectors
USB 2.0: gray (left)
USB 3.0: blue (right)

USB 3.0 comparison with other common interfaces

Interface	External synchronization	Shading Correction	Max. Pixel frequency	External power required	Data cable length	PC Interface	System-costs
USB 3.0	x	x	150 MHz	-	5 m	USB 3.0	low
GigE Vision	x	x	120 MHz	x	100 m	Gigabit Ethernet	medium
Camera Link	x	x	210 MHz (3 x 70 MHz)	x	10 m	PCI/PCIe -slot	high

The major characteristics can be compared for the USB 3.0 interface and a representative set of modern line scan camera interfaces.
USB 3.0 offers a fast data transfer at relatively low system costs while providing a future-proof operation of the line scan camera at its maximum bit-depth and speed.

USB Cable

USB 3.0 Cable
for connecting a USB 3.0 line scan camera to a PC

Connectors:
Camera: USB 3.0 plug, type µB, with lock screws
PC: USB 3.0 plug, type A (also fits a USB 2.0 type A socket

Order Code

SK9020.3	3 m length
SK9020.5	5 m length

Cable for external synchronization

Cable for External Synchronization
of line scan cameras with USB 3.0 interface

Connectors:
Hirose plug HR10A, female 6-pin (for camera)
Phoenix 6-pin connector incl. terminal block

Order Code

SK9026.3	3 m length
SK9026.5	5 m length

External Power Supply

Power cable

Combined Synchronization and Power Cable
for line scan cameras with USB 3.0 interface

Connectors:
Hirose plug HR10A, female 6-pin (for camera)
Phoenix 6-pin connector incl. terminal block

Order Code

SK9016.1.5	1.5 m length

Power Supply Unit

Power Supply PS051515

Order Code

Input:
- 100–240 V AC
- 0.8 A
- 50/60 Hz

Connector IEC 320 (3-pin)

Output:
- 5 V DC/2.5 A
- 15 V DC/0.5 A
- -15 V DC/0.3 A

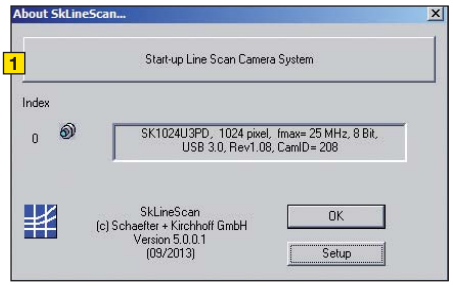
Connector Lumberg KV60 (female 6-pin)

Software

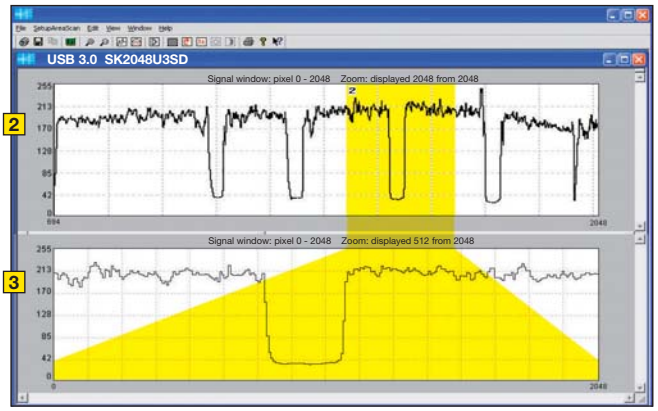
Software SK91USB3-WIN
SkLineScan
Control program
SDK with API und C++ class library

Order Code
SK91USB3-WIN

USB software package SK91USB3-WIN, SK91USB-LX



The USB software package **SK91USB3-WIN** for Windows7 and **SK91USB-LX** for Linux include the **SkLineScan®** software which enables the instant startup of the USB line scan camera 'out-of-the-box'. A software development kit (SDK), with DLLs and a class library for C++, offers a convenient method for producing individual user applications according to need.
The provided sample programs in C/C++ can be used as templates for the development of customized applications. Source comments and a manual facilitate the customized programming of the cameras.


USB 3.0 SK2048U3SD
Signal window: pixel 0 - 2048 Zoom: displayed 2048 from 2048
Signal window: pixel 0 - 2048 Zoom: displayed 512 from 2048

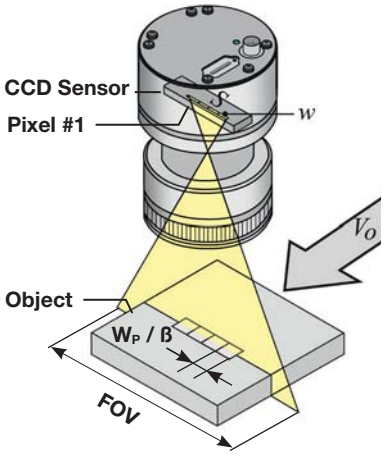
The **SkLineScan** software instantly recognizes the connected USB line scan camera and indicates the camera type.

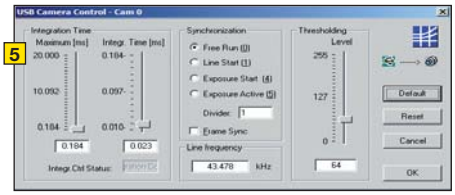
Oscilloscope display
With tools for adjustment of focus and aperture, for evaluating the field flattening of the lens and for aligning the illumination and sensor correctly.

Zoom function
Each individual camera pixel can be zoomed into. Online parameterization of the line scan camera uses pop-up dialogs, with changes implemented immediately for 'real-time' response control.

USB camera control
For adjusting integration time, line frequency, and synchronization mode.

6 Generating images





For a given object velocity the line frequency must be adjusted to provide an image with the correct aspect ratio, where:

$$f_L = \frac{V_O \cdot ß}{W_P}$$

V_O	=	object scan velocity
W_P	=	pixel width
f_L	=	line frequency
S	=	sensor length
FOV	=	field of view
ß	=	magnification (= S / FOV)

1 'About SkLineScan' shows camera information
2 Oscilloscope display of line scan signal
3 Zoomed part of scan 2 for 512 pixels
4 Scan object 2 as a 2-dimensional image
5 Camera control for integration time, sync mode
6 Generating a 2-dimensional image

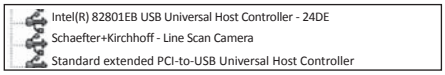
SDK for USB line scan cameras

C++ class library *)

Csk – Base class	
struct sk_interface	Communication structure for the driver
CskInit : Csk – Initializing class	
::Camera	Initialize the camera
::AllocBuffer	Allocate memory in the user area
::FreeBuffer	Release memory
::SetUserBufferPtr	Set pointer to user buffer
CskCtrl : Csk – Control class	
::SetIntegrationTime	Set integration time (ms)
::SetLineFrequency	Set line frequency (kHz)
::SetSyncMode	Set synchronization mode
::SetGain	Set camera gain
::SetOffset	Set camera offset
CskRecord : Csk – Acquisition class	
::SingleLineScan	Get a single line scan
::AreaScan	Acquire a 2D scan
::ContinuousGrab	Start continuous grab
::GetImage	Get single image from a continuous grab
::StopContinuousGrab	Stop continuous grab
CskView : Csk – View class	
::LineScanView	Display a line scan signal
::AreaScanView	Display an area scan
CskInfo : Csk – Information class	
::GetCamType	Name of current camera
::GetPixWidth	Number of current camera pixels
::GetLineFrequency	Current line frequency in kHz
::GetUserBufferPtr	Pointer to data set in user memory

*) Examples from the class library containing more than 60 methods for controlling the USB line scan camera

Installation of the USB line scan camera

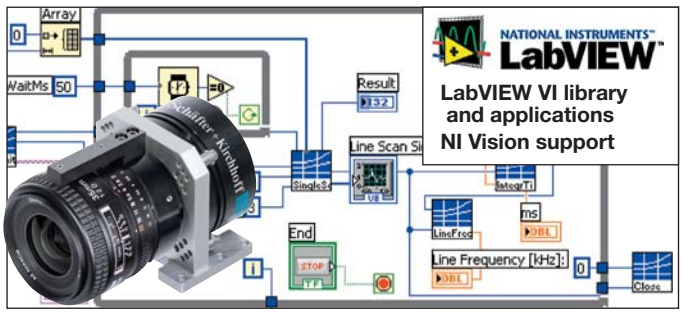

Intel(R) 82801EB USB Universal Host Controller - 24DE
Schaefter+Kirchhoff - Line Scan Camera
Standard extended PCI-to-USB Universal Host Controller

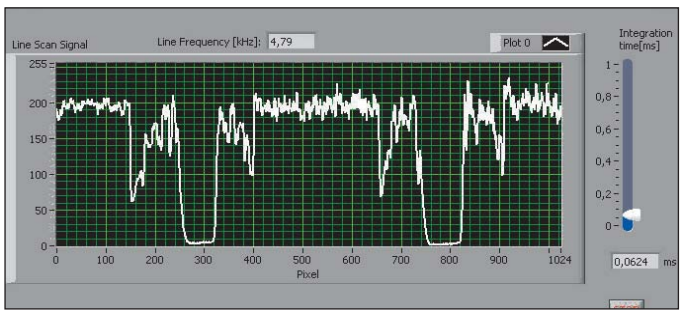
The LED on the rear of the camera casing glows red when the camera is plugged into a computer USB socket supplying sufficient power. No red light means that the camera requires an external source of power. A first-time installation is detected by the System Manager with a request to install the requisite driver, which is automatically installed from the supplied CD SK91USB3-WIN. The correct installation produces a System Manager entry for **Schäfter+Kirchhoff** – Line Scan Camera under USB Controller. The camera casing LED should now glow green and the USB line scan camera is now ready for use.

Software for USB line scan cameras

	Order code	Operating System
	SK91USB3-Win	Windows 7 x86/x64
	SK91USB-Win	Windows XP/2000
	SkLineScan Control program **SDK** with DLLs and C++ class library	
LabVIEW	SK91USB3 -LV	Windows/Labview
	SK91USB-LX	Linux 2.4/2.6

USB line scan cameras and LabVIEW





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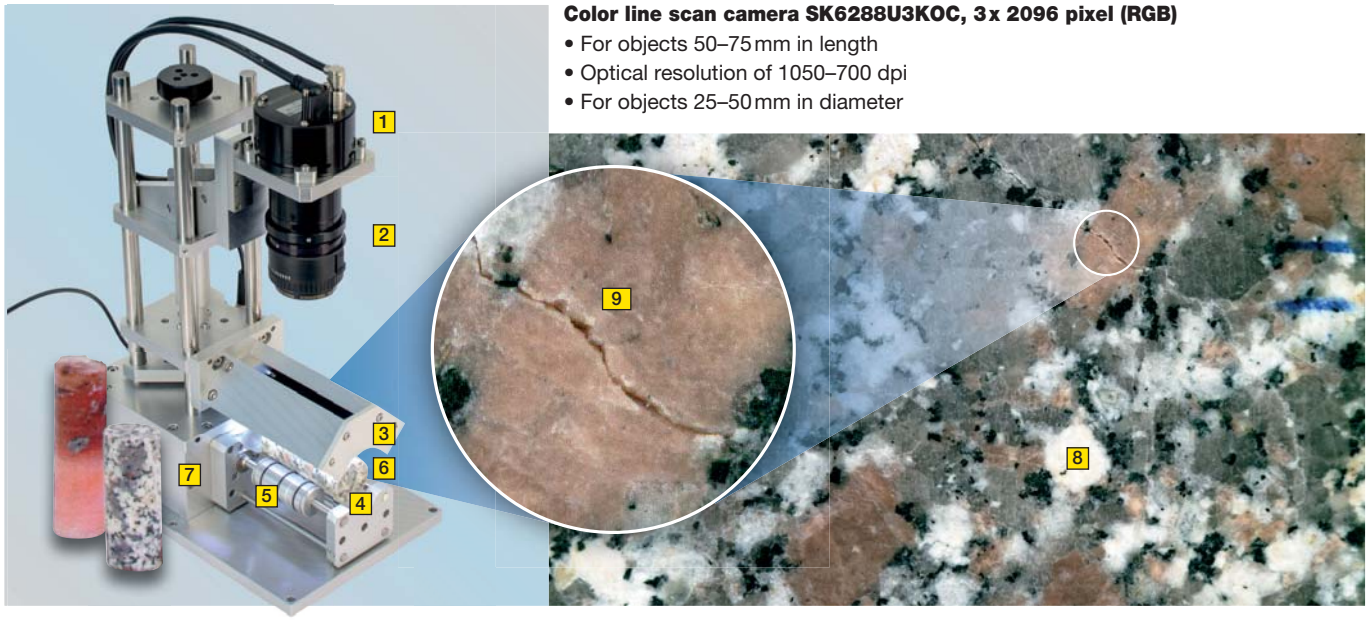
Specialized application
Plug Scanner SK-2096-USB3-Color
for automated bore plug inspection

USB 3.0



Color line scan camera SK6288U3KOC, 3 x 2096 pixel (RGB)
- For objects 50–75 mm in length
- Optical resolution of 1050–700 dpi
- For objects 25–50 mm in diameter

1 Color line scan camera SK6288U3KOC with USB 3.0 interface
2 Macro lens
3 Illumination (2 linear white LEDs)
4 Test specimen:
Bore plug, Ø1.5", length 3"
5 Driven rotator
6 Passive rotator (hidden)
7 Stand and housing for motor and electronics
8 Generated surface of bore plug
9 Zoom detail of bore plug surface

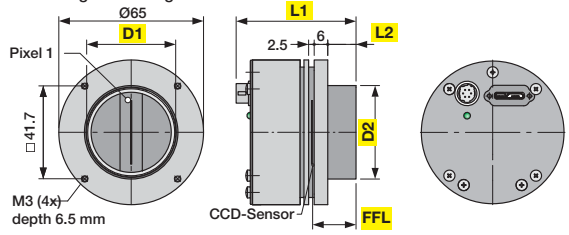
The bore plug scanner SK-2096-USB3-Color is a fully mobile surface-scanning macroscope that was specially developed by Schäfter+Kirchhoff for the investigation of smooth and cylindrical objects, such as bore plugs.

Features:
- Rapid and precise exchange of test objects by using two rotating supports
- Simple adjustment of focus for objects with different diameters
- The new USB 3.0 interface makes the operation of the scanner highly flexible so that it can be used almost anywhere
- A surface scan is performed by simply pressing a key or mouse button
- Automatic white balance
- One-click zooming for 1:1 depictions
- Printing and saving of total or zoomed sections

Dimensions

AT...

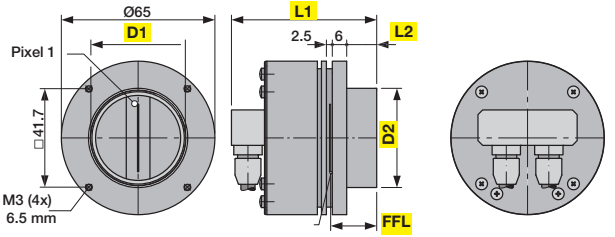
Lens mount: D1
Seat for bracket: D2
Flange focal length: FFL



Casing	D1 (Lens mount)	L1 (mm)	L2 (mm)	D2 (mm)	FFL (mm)
AT1	C-Mount	59.90	11.10	42.00	17.54
AT2	M40x0.75	61.50	12.70	42.00	19.50
AT3	M45x0.75	61.20	12.40	47.50	19.50

AU...

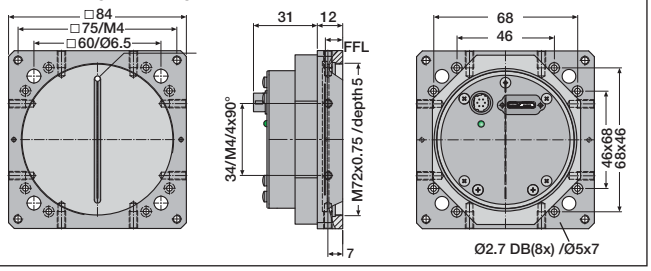
Lens mount: D1
Seat for bracket: D2
Flange focal length: FFL



Casing	D1 (Lens mount)	L1 (mm)	L2 (mm)	D2 (mm)	FFL (mm)
AU1	C-Mount	59.90	11.10	42.00	17.54
AU2	M40x0.75	61.50	12.70	42.00	19.50
AU3	M45x0.75	61.20	12.40	47.50	19.50

CT5

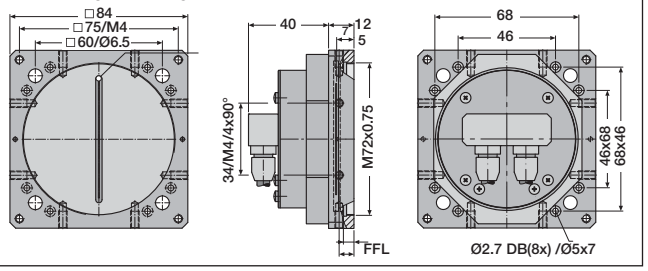
Lens mount: M72 x 0.75 mm
Flange focal length: FFL = 8 mm



CT5 ET5 FT7 see Line Scan Camera Family XL/XB/XC, p. 36

CU5

Lens mount: M72 x 0.75 mm
Flange focal length: FFL = 8 mm



CU5 see Line Scan Camera Family XL/XB/XC, page 36

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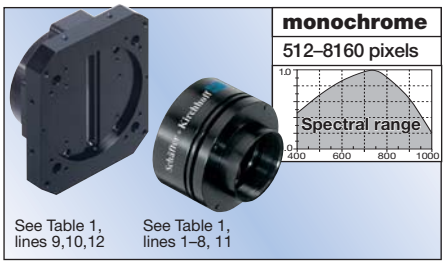
Schäfter+Kirchhoff

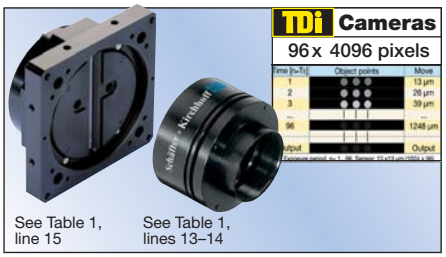
Line Scan Cameras

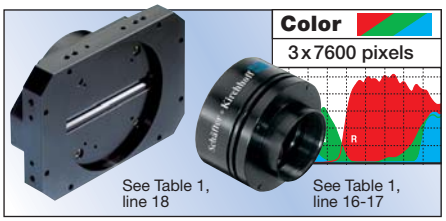
from 512 to 8160 pixels, monochrome, color or TDi

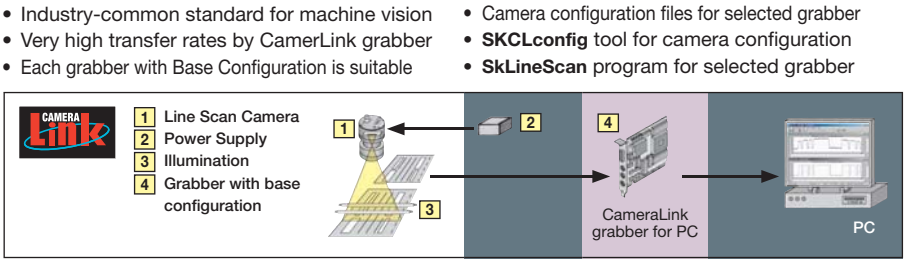
Interfaces: CameraLink

- Industry-common standard for machine vision
- Very high transfer rates by CamerLink grabber
- Each grabber with Base Configuration is suitable
- Camera configuration files for selected grabber
- **SKCLconfig** tool for camera configuration
- **SkLineScan** program for selected grabber









Features	
Line frequency	max. 83 kHz
Shading correction	X
External synchronization	X
Data cable length	10 m
Frame grabber specification	base configuration
Software / SDK	from grabber manufacturer

SK1024CSD with mounting bracket SK5105 and CCTV lens

SK2048CPD with mounting bracket SK5105 and photo lens SK1.4/50-40 (integrated focus/aperture adjustment)

SK4096CTDI-XL (camera casing CG5) with focus adapter FA26-S45, extension ring ZR-L..., adapter M39-45 and macro lens Apo-Rodagon D1x4.0/75 mm for 1:1 depictions of the scanned object

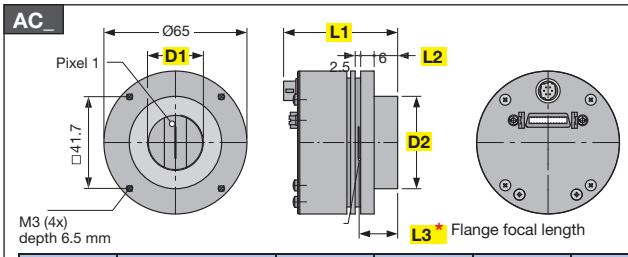
Accessories

	Page
Lenses and lens adapters	39–43
Extension rings	39–43
Camera mounting brackets	43
Connection cables, external power supplies	38

Table 1

Interface		Line scan camera	Pixels	Pixel frequency, max.	Line frequency, max.	Video signal	Pixel size	Active length	Anti-Bloom	Integr. Ctrl.	Dynamic range (RMS)	Power supply	Camera casing	Lens thread
		Order code	1	2	3	4	5	6	7	8	9	10	11	12
CameraLink	1	SK512CSD	512	30 MHz	53.5 kHz	8/12 Bit	14 x 14 µm	7.17 mm	x	x	1:2500	+5V, +15V	AC1	C-Mount
	2	SK1024CPD	1024	50 MHz	45.0 kHz	8/12 Bit	10 x 10 µm	10.24 mm	x	x	1:1500	+5V, +15V	AC1	C-Mount
	3	SK1024CSD	1024	30 MHz	28.0 kHz	8/12 Bit	14 x 14 µm	14.30 mm	x	x	1:2500	+5V, +15V	AC1	C-Mount
	4	SK2048CJR	2048	10 MHz	4.73 kHz	8 Bit	14 x 14 µm	28.70 mm	-	x	1: 625	+5V, +15V	AC2	M40x0.75
	5	SK2048CPD	2048	50 MHz	23.00 kHz	8/12 Bit	10 x 10 µm	20.50 mm	x	x	1:1500	+5V, +15V	AC2	M40x0.75
	6	SK2048CSD	2048	30 MHz	14.3 kHz	8/12 Bit	14 x 14 µm	28.70 mm	x	x	1:2500	+5V, +15V	AC2	M40x0.75
	7	SK4096CPD-L	4096	50 MHz	11.9 kHz	8/12 Bit	10 x 10 µm	41.00 mm	x	x	1:2500	+5V, +15V	AC3	M45x0.75
	8	SK5150CJR	5148	40 MHz	7.56 kHz	8 Bit	7 x 7 µm	36.00 mm	-	-	1: 500	+5V, +15V	AC2	M40x0.75
	9	SK7500CTF-XB	7500	80 MHz	10.10 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	1:1000	+5V, +15V	EC5	M72x0.75
	10	SK7500CTO-XL	7500	40 MHz	5.2 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	1: 750	+5V, +15V	CC5	M72x0.75
	11	SK8160CKO-LB	8160	100 MHz	11.90 kHz	8/12 Bit	5 x 5 µm	40.80 mm	x	x	1:2500	+5V, +15V	AC3	M45x0.75
	12	SK8160CKO-XL	8160	100 MHz	11.9 kHz	8/12 Bit	5 x 5 µm	40.80 mm	x	x	1:2500	+5V, +15V	CC5	M72x0.75
	13	SK1024CTDI	96 x 1024	50 MHz	43.4 kHz	8/12 Bit	13 x 13 µm	13.30 mm	x	-	1:2500	+5V, +15V	AC2	M40x0.75
	14	SK2048CTDI	96 x 2048	100 MHz	43.40 kHz	2*8 Bit	13 x 13 µm	26.60 mm	x	-	1:2500	+5V, +15V	AC2	M40x0.75
	15	SK4096CTDI-XL	96 x 4096	100 MHz	22.30 kHz	2*8 Bit	13 x 13 µm	53.20 mm	x	-	1:2500	+5V, +15V	CC5	M72x0.75
	16	SK6288CKOC	3 x 2096	60 MHz	9.28 kHz	8/12 Bit	14 x 14 µm	29.30 mm	-	x	1:2500	+5V, +15V	AC2	M40x0.75
	17	SK12240CKOC-LB	3 x 4080	60 MHz	4.80 kHz	8/12 Bit	10 x 10 µm	40.80 mm	x	x	1:2500	+5V, +15V	AC3	M45x0.75
	18	SK22800CJRC-XC	3 x 7600	50 MHz	6.17 kHz	3*8 Bit	9.3 x 9.3 µm	70.87 mm	-	-	1:1000	+5V, +15V	FC7	M72x0.75

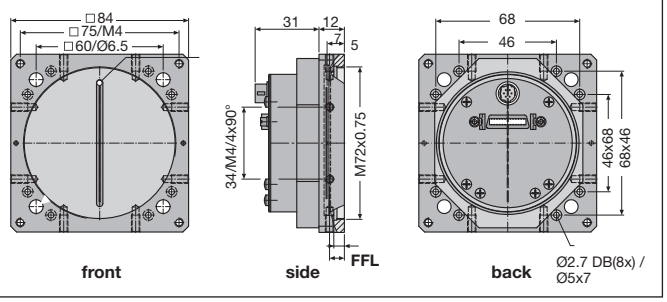
AC_



Casing	D1 (Lens mount)	L1 (mm)	L2 (mm)	D2 (mm)	L3 (mm)
AC1	C-Mount	52.40	11.10	42.00	17.54
AC2	M40x0.75	54.00	12.70	42.00	19.50
AC3	M45x0.75	53.70	12.70	47.50	19.50

CC5

Lens mount: M72x0.75mm
Flange focal length: FFL = 8mm



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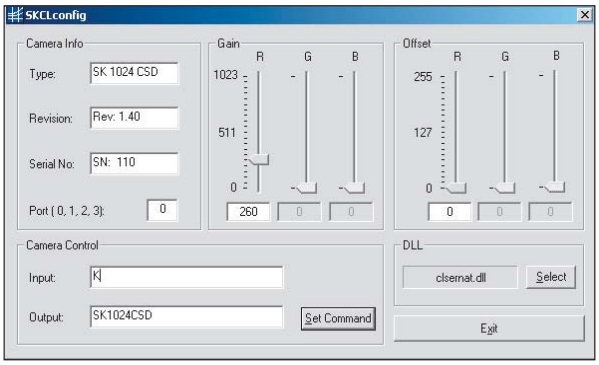
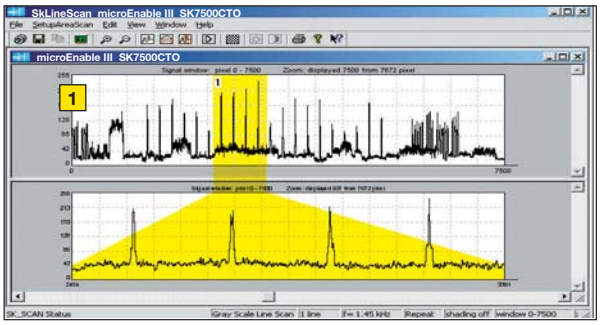
Configuration program SkCLconfig

The configuration program **SkCLconfig** is shipped with all **Schäfter+Kirchhoff** cameras and enables the adjustment of line scan camera parameters, such as gain, offset, and pixel frequency, via the serial connector of the CameraLink interface. The software uses the *clser***.dll* supplied with the CameraLink grabber board or a choice is made from the installed *clser*.dll* list using **Select**. The parameter settings are stored in the camera memory and are retained for immediate subsequent use even after a complete shut down.



Operating program SkLineScan: oscilloscope display

Any grabber board with a CameraLink base configuration can be used for controlling the line scan cameras from **Schäfter+Kirchhoff** and the SDK of the grabber manufacturer must be used for developing application software. Unfortunately, CameraLink grabber boards and their associated software are designed for area cameras and usually do not support line scan formats. For selected grabber boards, including Matrox Solios, National Instruments PCI-1428, DALSA X64 Xcelera-CL and microEnable III, **Schäfter+Kirchhoff** provides the **SkLineScan**® operating program. The oscilloscope display provides a plot of the line scan signals, which can be fully zoomed to individual pixels over a selected area, and enables the parameterization and setup of the camera and optical system.



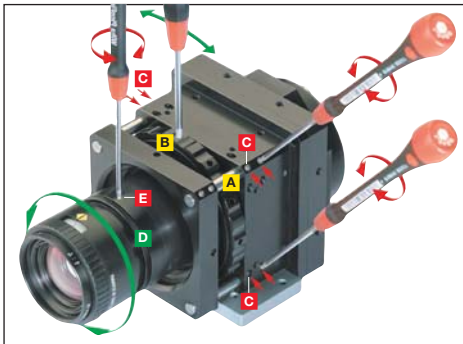
1 Oscilloscope display
A highly convenient tool for the adjustment of focus, aperture settings and the evaluation of field flattening of the lens. The zoom function can display the signal for individual pixels over a freely selectable sensor length. The software can be adapted for other standard specification CameraLink grabber boards.

Camera commands

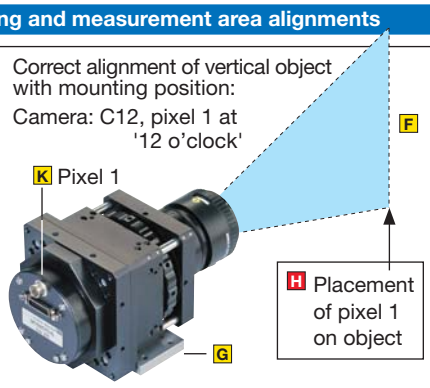
Operation	Description
Gnnnn<CR>	Set Gain Chan1 (Red) 0-24 dB
Bnnnn<CR>	Set Gain Chan2 (Green) 0-24 dB
Hnnnn<CR>	Set Gain Chan3 (Blue) 0-24 dB
Jnnnn<CR>	Set Gain Chan4 0-24 dB
Ommm<CR>	Set Offset Chan1 (Red)
Pmmm<CR>	Set Offset Chan2 (Green)
Qmmm<CR>	Set Offset Chan3 (Blue)
Ummm<CR>	Set Offset Chan4
F8<CR>	Output Format: 8-bit data
F12<CR>	Output Format: 12-bit data
C30<CR>	Camera Clock: 30 MHz
C60<CR>	Camera Clock: 60 MHz
CC3<CR>	Camera Clock external at CC3 (max. 60 MHz / optional)
T0<CR>	Test pattern off
T1<CR>	Test pattern on
M1<CR>	Trigger Mode: External Trigger CC1
M2<CR>	Free Run with maximum line rate
M3<CR>	External Trigger & Integration CC1-input, optional
M4<CR>	External Trigger CC1, Integration CC2- input, optional
I<CR>	returns camera identification
K<CR>	returns SK type number
R<CR>	returns Revision number
S<CR>	returns Serial number
I4<CR>	returns Camera Clock Low Freq.
I5<CR>	returns Camera Clock High Freq.
I6<CR>	Ga1:xxxxx<CR> ret.Gain Chan1
I7<CR>	Ga2:xxxxx<CR> ret.Gain Chan2
I10<CR>	Ga3:xxxxx<CR> ret.Gain Chan3
I11<CR>	Ga4:xxxxx<CR> ret.Gain Chan4
I8<CR>	Of1:xxxxx<CR> ret.Offset Chan1
I9<CR>	Of2:xxxxx<CR> ret.Offset Chan2
I12<CR>	Of3:xxxxx<CR> ret.Offset Chan3
I13<CR>	Of4:xxxxx<CR> ret.Offset Chan4
Range of values:	nnnn = 0...1023, mmm = 0...255.

Camera commands are entered into the 'Input' field of the configuration tool and executed with the 'Set Command'

Line scan camera series ...-XL: lens focussing and measurement area alignments



Correct alignment of vertical object with mounting position:
Camera: C12, pixel 1 at '12 o'clock'



A Linear tracking rods for precise travel of focussing encasement

B Focussing ring, ±15 mm (1 turn = 10 mm)

C Screw for locking the focussing encasement, hex Allen Key SW 1.5

D Rotatable lens extension ring for correct alignment of azimuth, lens thread M39x1/26"

E Screw for locking the lens housing, hex Allen Key SW 1.5

Correct alignment of the measurement area **F** can be achieved in four possible positions of the mounting plate **G**

H For a measurement area vertical to the mounted camera. The lens captures the lowest point of the scanned object at sensor pixel 1

I A measurement area parallel to the mounted camera. The lens captures the extreme right point of the object at sensor pixel 1

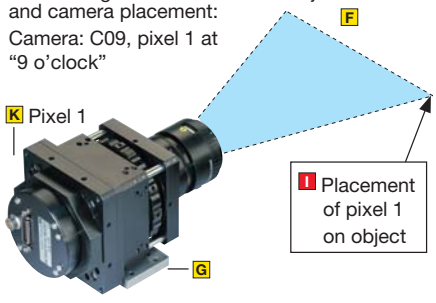
Camera back view

2 Power
Hirose series 10A, male 6-pin
5 V DC/430 mA
15 V DC/ 35 mA

1 Data: Mini-D Ribbon, female 26-pin

Pin	Signal	Pin	Signal
1	+15 V	4	+ 5 V
2	+15 V	5	GND
3	+ 5 V	6	GND

Correct alignment of horizontal object and camera placement:
Camera: C09, pixel 1 at "9 o'clock"



The position of the power input **K** indicates the location of sensor pixel 1 for cameras with a CameraLink interface

Accessories for Line Scan Cameras with CameraLink interface

**Control cable SK9018...
for line scan cameras
with CameraLink interface**

26-pin shielded cable, both ends with mini-ribbon connector (male 26-pin)

SK9018.5-MM Order-Code
- MM = Connector both ends (male)
- 3 = 3 m cable length
- 5 = 5 m (standard cable length)
- x = chosen length (maximum = 10 m)

**Cable for power supply SK9015...
for line scan cameras with
CameraLink interface**

Shielded cable with connectors: Lumberg SV60 (male 6-pin) and Hirose HR10A (female 6-pin)

SK9015.1.5MF Order Code
- MF = Connector (male /female)
- 1.5 = 1.5 m (standard)
- 3 = 3 m
- x = chosen length

**Power Supply
PS051515**
Order Code

Input:
- 100–240 V AC
- 0.8 A
- 50/60 Hz

3-pin input connector (IEC 320)

Output:
- 5 V DC/2.5 A
- 15 V DC/0.5 A
- -15 V DC/0.3 A

output connector:
Lumberg KV60, female 6-pin, length 1 m

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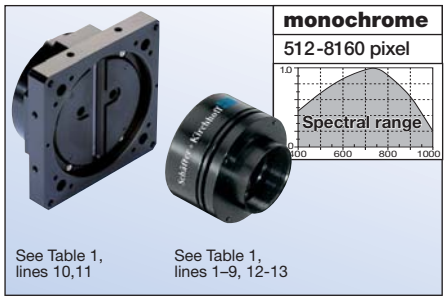
Schäfter+Kirchhoff

Line Scan Cameras
from 512 to 8160 pixels, monochrome or color

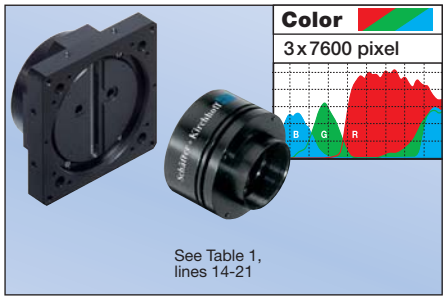
Interface: LVDS
Low Voltage Differential Signalling

- Legacy multi-camera system for industry
- Proven and rugged platform with external data acquisition and data analysis
- All system components provided by S+K
- In-house line scan grabbers (e.g. SK9193D)
- External power supply is not necessary
- Merger Boxes for connecting up to either 3 or 5 cameras to one line scan grabber

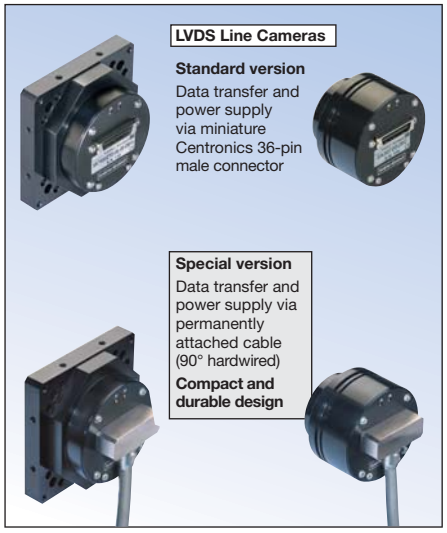


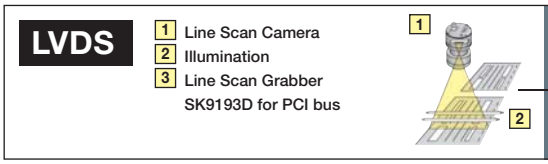
See Table 1, lines 10,11

See Table 1, lines 1–9, 12-13



See Table 1, lines 14-21


LVDS Line Cameras
Standard version
Data transfer and power supply via miniature Centronics 36-pin male connector
Special version
Data transfer and power supply via permanently attached cable (90° hardwired)
Compact and durable design



Features	
External synchronization	X
Shading correction	X
Windowing (ROI)	X
Thresholding	X
Windows, LabVIEW, Linux	SK91PCI-WIN, -LV, -LX

SK2048DPD
with mounting bracket SK5105 and photo lens SK1.4/50-40 (integrated focus and aperture adjustment)

SK4096DPD-L
with focus adapter FA22R-45, mounting brackets SK5105-2L, extension ring ZR-L.., macro lens Apo-Rodagon D1x 2.5/75 mm for 1:1 depictions of a scanned object

SK7500DTO-XL
with focus adapter FA26-S45, extension ring ZR-L.., adapter M39-45 and macro lens ApoRodagon D1x 2.5/75 mm for 1:1 depictions of a scanned object

Table 1

Interface		Line scan camera	Pixels	Pixel frequency, max.	Line frequency, max.	Video signal	Pixel size	Active length	Anti-Bloom	Integr. Ctrl.	Dynamic range (RMS)	Power supply	Camera casing	Lens thread
		Order code	1	2	3	4	5	6	7	8	9	10	11	12
LVDS	1	SK512ZSD	512	30 MHz	52.0 kHz	8/12 Bit	14 x 14 µm	7.17 mm	x	x	1:5000	+5V, +15V, -15V	AL1	C-Mount
	2	SK1024ZPD	1024	50 MHz	43.4 kHz	8/12 Bit	10 x 10 µm	10.24 mm	x	x	1:2500	+5V, +15V, -15V	AL1	C-Mount
	3	SK1024ZSD	1024	30 MHz	27.5 kHz	8/12 Bit	14 x 14 µm	14.30 mm	x	x	1:5000	+5V, +12V, -12V	AL1	C-Mount
	4	SK2048DDW	2048	10 MHz	4.80 kHz	8 Bit	13 x 500 µm	26.60 mm	x	x	1:2000	+5V, +15V, -15V	AL2	M40x0.75
	5	SK2048DJRI	2048	10 MHz	4.80 kHz	8 Bit	14 x 14 µm	28.70 mm	-	x	1: 500	+5V, +12V, -12V	AL2	M40x0.75
	6	SK2048ZPD	2048	50 MHz	23.0 kHz	8/12 Bit	10 x 10 µm	20.50 mm	x	x	1:2500	+5V, +15V, -15V	AL2	M40x0.75
	7	SK2048ZSD	2048	30 MHz	14.2 kHz	8/12 Bit	14 x 14 µm	28.70 mm	x	x	1:5000	+5V, +15V, -15V	AL2	M40x0.75
	8	SK4096ZPD-L	4096	50 MHz	11.90 kHz	8/12 Bit	10 x 10 µm	41.00 mm	x	x	1:2500	+5V, +15V, -15V	AL3	M45x0.75
	9	SK5150ZJR	5150	40 MHz	7.53 kHz	8/12 Bit	7 x 7 µm	36.00 mm	-	-	1: 500	+5V, +15V, -15V	AL2	M40x0.75
	10	SK7500DTO-XL	7500	40 MHz	5.2 kHz	8 Bit	7 x 7 µm	52.50 mm	-	-	1: 750	+5V, +15V, -15V	CL5	M72x0.75
	11	SK7500ZTO-XL	7500	40 MHz	5.20 kHz	8 Bit	7 x 7 µm	52.50 mm	-	-	1: 750	+5V, +15V	CL5	M72x0.75
	12	SK8160ZKO-LB	8160	60 MHz	7.15 kHz	8 Bit	5 x 5 µm	40.80 mm	x	x	1:2500	+5V, +15V	AL3	M45x0.75
	13	SK10680DJR-L	10680	5 MHz	0.46 kHz	8 Bit	4 x 4 µm	42.72 mm	-	-	1:1000	+5V, +15V, -15V	AL3	M45x0.75
	14	SK3072DJRC	1024 + 2048	6 MHz	1.85 kHz	8 Bit	12 x 14 µm	28.70 mm	-	-	1: 500	+5V, +12V, -12V	AL2	M40x0.75
	15	SK3750DJRC	3 x 1252	20 MHz	4.80 kHz	8 Bit	8 x 8 µm	10.00 mm	-	x	1:1000	+5V, +15V, -15V	AL2	M40x0.75
	16	SK4096DJRC	2 x 2048 *	15 MHz	3.5 kHz	8 Bit	12 x 14 µm	28.70 mm	-	-	1:1000	+5V, +15V, -15V	AL2	M40x0.75
	17	SK6288ZKOC	3 x 2096	60 MHz	9.28 kHz	8/12 Bit	14 x 14 µm	29.30 mm	-	x	1:2500	+5V, +15V	AL2	M40x0.75
	18	SK8100DJRC	3 x 2700	20 MHz	2.47 kHz	8 Bit	8 x 8 µm	21.60 mm	-	-	1:1000	+5V, +15V, -15V	AL2	M40x0.75
	19	SK10944DJRC	3 x 3648	20 MHz	1.79 kHz	8 Bit	8 x 8 µm	29.20 mm	-	x	1:1000	+5V, +15V, -15V	AL2	M40x0.75
	20	SK12240ZKOC-LB	3 x 4080	60 MHz	4.80 kHz	8 Bit	10 x 10 µm	40.80 mm	x	x	1:2500	+5V, +15V	AL3	M45x0.75
	21	SK16080DJRC-L	3 x 5360	20 MHz	1.22 kHz	8 Bit	8 x 8 µm	42.90 mm	-	x	1:1000	+5V, +15V, -15V	AL3	M45x0.75

* Dual Line Sensor with 2048 pixels for green and 1024 alternating pixels each for red and blue (see page 33)

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Line Scan Grabber with LVDS interface

Line Scan Grabber
SK9190D, SK9192D, SK9193D
PCI bus, pixel-clock digital cameras:
30 / 40 / 60 MHz

Line scan camera grabbers supply control signals and power for the operation of the line scan cameras. As the interface between PC and camera, they transmit line signals to the PC memory and enable the setting of camera parameters (integration time, synchronization, pixel and line frequencies).
Special on-board preprocessing functions accelerate signal evaluation in the PC, such as shading correction, windowing (ROI) and thresholding.
Library functions from the software package SK91PCI-xxx* and the operating software **SkLineScan®** support the programming of the line scan grabber.

* xxx = operating systems: WIN, LX (Linux)

Line Scan Grabber

SK 9192D . 32 Order Code

- SK 9192D: Board type
- 32: FIFO memory in kBytes, see table for size

Accessories

Line scan grabber SK9192D, SK9193D
for controlling line scan cameras with LVDS interface, PCI bus, on-board features: shading correction, thresholding, windowing (ROI).

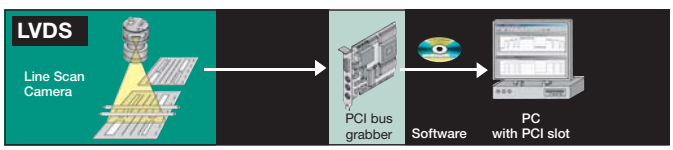
Merger box SK9194 (for up to 3 cameras)
SK9195 (for up to 5 cameras)
For the control of up to 3 or 5 line scan cameras from only one line scan grabber board, providing free programmable or pixel synchronous acquisition of all connected cameras.

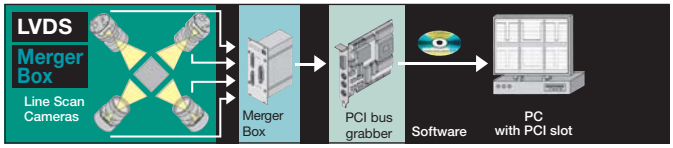
Software SK91PCI-WIN, -LX
Operating program **SkLineScan**, SDK with DLLs, class libraries and many worked examples.
Windows 7(x86)/XP, LabVIEW and Linux.

Synchronization box SK8051
Programmable pulse divider with jitter suppression for the external synchronization of image acquisitions.

SK9019.3FF
Connection cable for LVDS line scan cameras
Shielded cable for camera/video signals and power supply, standard: 3 m, single or double-ended with Centronics connectors (female 36-pin).

System components





Application

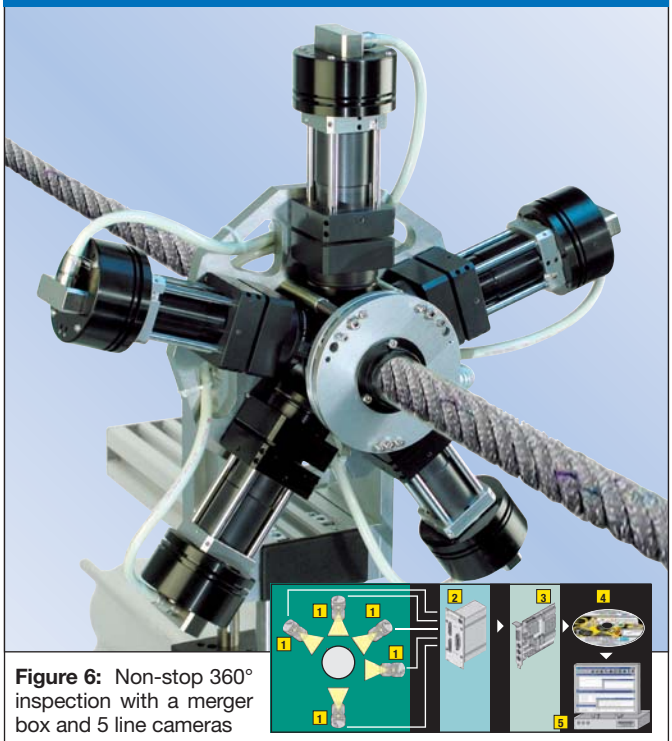
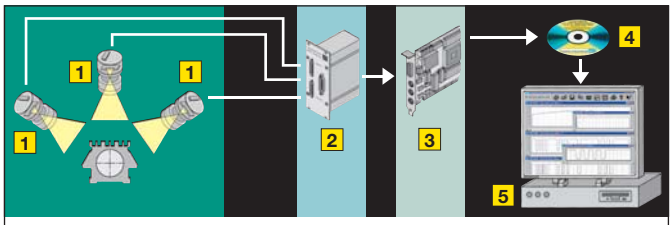


Figure 6: Non-stop 360° inspection with a merger box and 5 line cameras

Application 1: Continuous 360° surface inspection during cable production using synchronous measurements from five identical line cameras of the SK512DPD type



Application 2: Continuous surface inspection of a profile using synchronous data collection from three line scan cameras with different sensor lengths, e.g. 1x SK1024DPD, 2x SK512DPD.
The inspection of a turned object or extrusion profile requires data to be obtained in various ways for deconvolution in the PC.
An appropriate combination of different cameras, with various sensor lengths or characteristics, enables exploitation of the resolution and reflective properties of the scanned objects in order to produce highly discriminating applications for both measurement and monitoring.
For an example of 3 cameras in Scheimpflug configuration, see page 55.

System components

1 CCD line scan camera
2 Merger box SK9194 / SK9195
3 Grabber SK9193D / SK9192D
4 Software SK91PCI-WIN,-LV,-LX *
5 PC (Intel x86, PCI-Bus)
* WIN= WIN 7 / XP, LV= LabVIEW, LX= Linux

Merger Box **SK 9194...** for up to 3 cameras
SK 9195... for up to 5 cameras

SK 9195-P-8-1 Order Code

- Factory-preset operating mode and divisor:
  1 = operating mode 1, divisor 1
  2 = operating mode 2, divisor 2
  3 = operating mode 2, divisor 3
  4 = operating mode 2, divisor 4
- FIFO memory per camera:
  8 = 8 kbytes (standard)
  16 = 16 kbytes
  32 = 32 kbytes
- Factory-preset power setting as either:
  P = power supply from PC interface card, or
  E = external power supply

Connection cable SK 9019...
SK 9019.3 FF Order Code Cable length in m
3 = 3 m (standard)
1 = 1 m
x = length of choice

External power supply PS051515
Order Code

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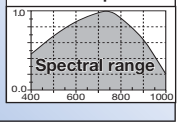
Line Scan Cameras
from 512 to 2048 pixels, monochrome or color

Interface: Analog

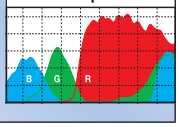
see Table 1, lines 1-4

monochrome
512-5150 pixels



see Table 1, line 5

Color
3x1024 pixels



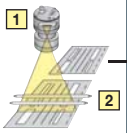
In order to function, an analog line scan camera needs a control signal or **Clock** (pixel frequency maximum of 10 MHz) and **SOS** (Start Of Scan) as well as a voltage supply of +5 V or +/-12 V.

The output of video data from an analog line scan camera is a variable voltage in the range from 0–10 V. Before the video data can be stored or used in a computer, a Line Scan Grabber SK9190 or an A/D converter module SK9158 is used to digitalize the signal.

The software package **SK91PCI-WIN (..-LX)** for Windows 7/XP (Linux) contains the display and control program **SkLineScan®** that allows use of the camera 'out-of-the-box'. The Software Development Kit (SDK) enables customized program applications to be developed.

Analog

1 Line Scan Camera
2 Illumination
3 Line Scan Grabber SK9190 for PCI bus



SK9190 PCI bus

PC with PCI slot

Components

	Page
Line scan camera	12, 13, 32
Lenses, focus adapters, extension rings	39–43
Mounting brackets	43
Line Scan grabber SK9190	28
Cables: SK9017.3 FF	38
Software: SK91PCI-WIN,-LV, SK91PCI-LX	10

Features

External synchronization	X
Shading correction	X
Windowing (ROI)	X
Thresholding	X
Windows, LabVIEW, Linux	SK91PCI-WIN, -LV, -LX

Gain/Offset adjustment

1. Offset: Without the sensor being illuminated, offset is adjusted using the potentiometer P2 to set the signal to 0 volt.

2. Gain: The sensor is slightly over-illuminated and the maximum output voltage of the camera is specified using P1, so that the maximum level remains just visible.

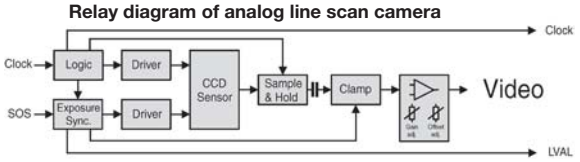
The maximum output voltage is set to 1.1 V by default but, upon request, an output of up to 10 volts can be factory-preset.

Connections/controls

Video OUT analog
BNC connector
Control
D-SUB, 15-pin, RS422 IN
Voltage
+5 V, +/- 12 V (+/-15 V)
Gain,Offset
Potentiometer on camera back

Connections and controls

Relay diagram of analog line scan camera

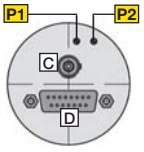


Input: Clock = pixel frequency, max. 10 MHz
SOS = Start Of Scan signal

Output: analog video (0–10 V)

Back view: analog line scan camera

Manual gain/offset adjustment is performed using the trimming resistors
P1 Gain adjustment
P2 Offset adjustment

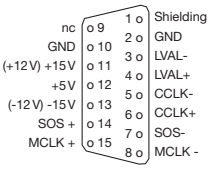


Pin assignment

C BNC connector

Video Out

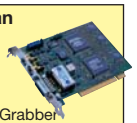
D female 15-pin D-SUB



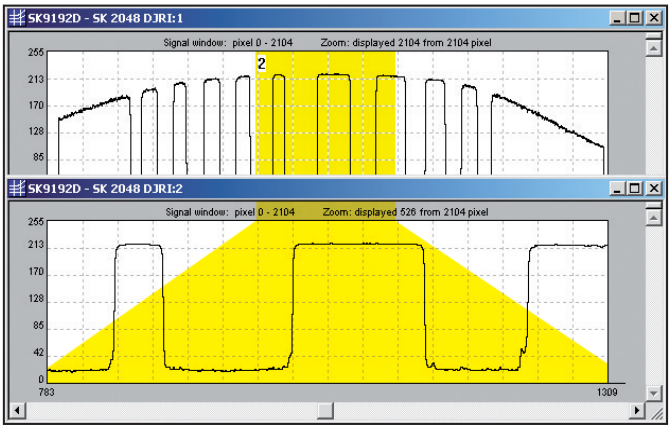
Software

Order Code	Operating System
SK91PCI-WIN	Windows 7/XP
SK91PCI-LX	Linux
SK91PCI-LV	LabVIEW

Line Scan Grabber SK9190



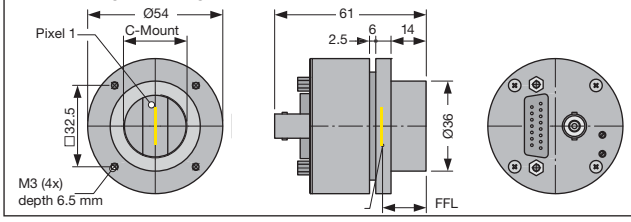
Line Scan Grabber for analog line scan cameras: **PCI bus,** preprocessing on-board, shading correction, ROI, thresholding, external synchronization.



Line scan signal using the software **SK91PCI-WIN**

RA1

Lens mount: C-Mount
Seat for bracket: Ø36 mm
Flange focal length: FFL = 17.5 mm



RA2

Lens mount: M40x0.75
Seat for bracket: Ø42 mm
Flange focal length: FFL = 19.5 mm

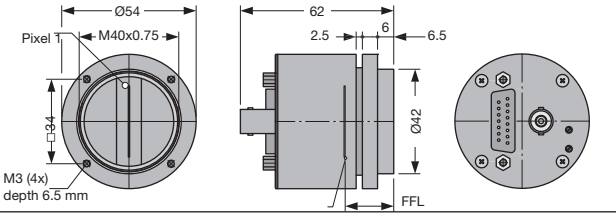


Table 1

Interface		Line scan camera	Pixels	Pixel frequency, max.	Line frequency, max.	Video signal	Pixel size	Active length	Anti-Bloom	Integr. Ctrl.	Dynamic range (RMS)	Power supply	Camera casing	Lens thread
		Order code	1	2	3	4	5	6	7	8	9	10	11	12
Analog	1	SK512SD	512	10 MHz	18.45 kHz	1/1-10 V	14 x 14 µm	7.17 mm	x	x	1:1500	+5V, +12V, -12V	RA1	C-Mount
	2	SK1024SD	1024	10 MHz	9.48 kHz	1/1-10 V	14 x 14 µm	14.30 mm	x	x	1:1500	+5V, +12V, -12V	RA1	C-Mount
	3	SK2048JRI	2048	5 MHz	2.37 kHz	1/1-10 V	14 x 14 µm	28.70 mm	-	x	1: 500	+5V, +12V, -12V	RA2	M40x0.75
	4	SK2048SD	2048	10 MHz	4.80 kHz	1/1-10 V	14 x 14 µm	28.70 mm	x	x	1:1500	+5V, +12V, -12V	RA2	M40x0.75
	5	SK3072JRC	2 x 1536	6 MHz	1.85 kHz	1/1-4 V	12 x 14 µm	28.70 mm	-	-	1: 500	+5V, +12V, -12V	RA2	M40x0.75

* More than 20 other analog line scan cameras are available and details can be supplied on request

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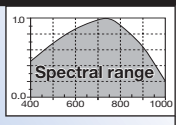
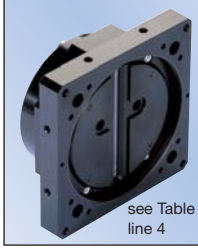
analog_ZK.indd • Page 28

Smart Line Scan Cameras

monochrome 1024–7500 pixels





Interface
USB 2.0

see Table 1, line 4

Table 1 lines 1-3

Stand-alone measuring system without PC

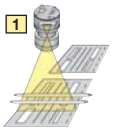
- Measuring of widths, edges, object positions
- Operation principle uses thresholding
- Measuring with subpixel accuracy
- Reproducible accuracy of 1 µm
- Results output via analog or RS232 interface
- PC is needed only for setup
- Setup and parameterization via USB 2.0

Interfaces: USB 2.0 | Analog | RS232

Setup: USB 2.0

Measuring: Analog RS232

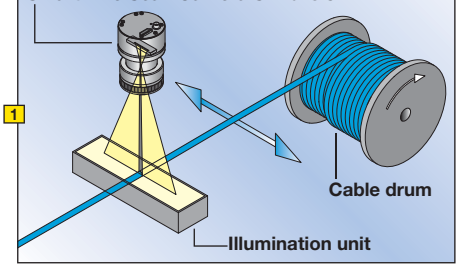
1 Smart line scan camera
2 Setup mode: USB 2.0
3 Outputs: 1x analog, 2x RS232



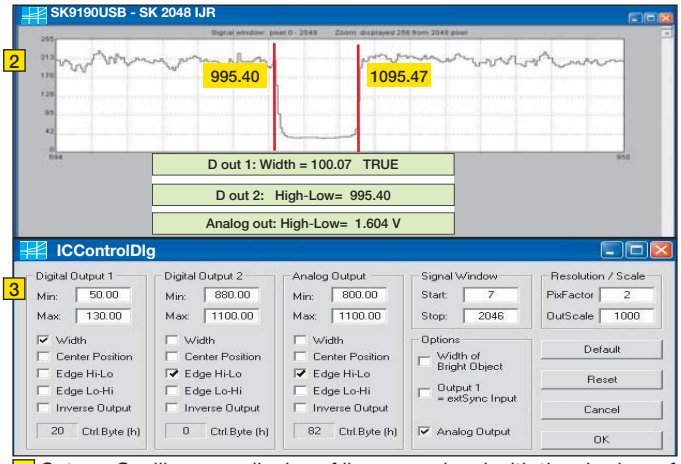
Features	
Measuring frequency	max. 3.3 kHz
Measuring	width, edge position
Reproducible accuracy	1 µm
External synchronization	X
Region Of Interest (ROI)	X
Output	1x analog, 2x digital (RS232)
Windows	SK91UIC-WIN

Application Cable drum winding control: measuring cable lateral motion

Smart Line Scan Camera SK2048IJR



1 With transmitted light, the cable generates a shadow at the line sensor and the cable position is provided as a voltage or digitally via RS232, e.g to the SPS.



2 Setup: Oscilloscope display of line scan signal with the shadow of the cable using transmitted light.
3 Dialog **ICControlDlg** for the selection of measurement and valid ranges for each of the three outputs in measuring mode.

I/O Interface

- USB 2.0, RS232, analog

Input: • Extern Sync.

Output:

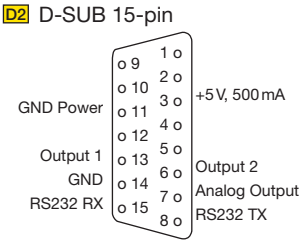
measuring mode
- 2x digital (open collector)
- 1x analog (0–3.3 V)

setup mode
- Video signal, 8-bit, USB 2.0

Power supply: PS0510IJR
- +5 V DC, 1.0 A, D-SUB 15-pin

Connector pin assignment

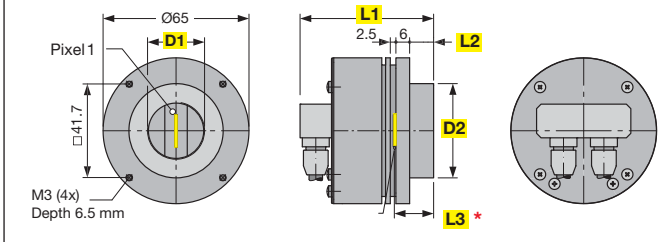
D2 D-SUB 15-pin



Output 1, Output 2: open collector, max. 24 V

Analog Output: 0–3.3 V

AU_



Casing	D1 (Lens mount)	L1 (mm)	L2 (mm)	D2 (mm)	L3 (mm)
AU1	C-Mount	59.90	11.10	42.00	17.54
AU2	M40x0.75	61.50	12.70	42.00	19.50
AU3	M45x0.75	61.20	12.70	47.50	19.50

CU5

Lens mount: M72x0.75 mm
Flange focal length: FFL = 8 mm

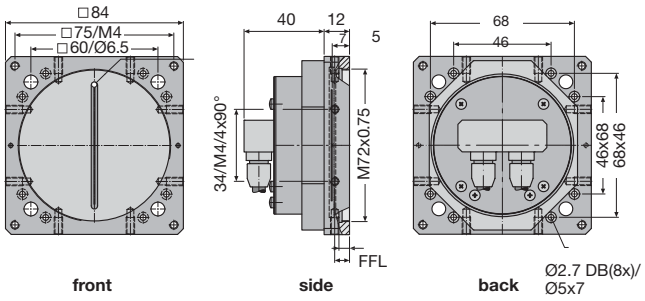
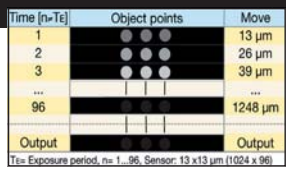


Table 1

Interface		Line scan camera	Pixels	Pixel frequency, max.	Line frequency, max.	Video signal	Pixel size	Active length	Anti-Bloom	Integr. Ctrl.	Dynamic range (RMS)	Power supply	Camera casing	Lens thread
		Order code	1	2	3	4	5	6	7	8	9	10	11	12
Analog RS232 / USB 2.0	1	SK1024ISD	1024	15 MHz	14.10 kHz	8 Bit	14 x 14 µm	14.34 mm	x	x	1:2500	+5V, 350 mA	AU1	C-Mount
	2	SK2048IJR	2048	10 MHz	4.73 kHz	8 Bit	14 x 14 µm	28.70 mm	-	x	1: 500	+5V, 350 mA	AU2	M40x0.75
	3	SK5148IJR	5148	10 MHz	1.90 kHz	8 Bit	7 x 7 µm	36.00 mm	-	-	1: 500	+5V, 350 mA	AU2	M40x0.75
	4	SK7500ITO-XL	7500	15 MHz	1.95 kHz	8 Bit	7 x 7 µm	52.50 mm	-	-	1: 750	+5V, 350 mA	CU5	M72x0.75

Line Scan Cameras
1024 x 96, 2048 x 96, 4096 x 96 pixels

TDi

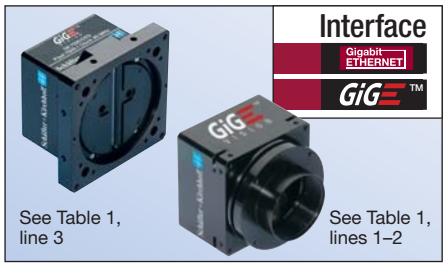


TDI Line Scan Cameras
Time Delay Integration Technology

TDi

Highlights of Time Delay Integration (TDI) Technology:

- Sensitivity 96-times greater than conventional line scan cameras
- Especially useful for dimly lit objects (e.g. wafer inspection with dark-field illumination)
- TDI cameras can achieve extremely high measurement and scan velocities



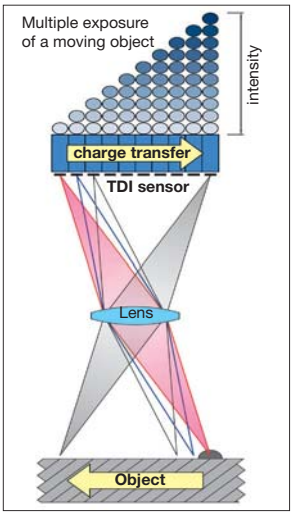
Accessories: Page

Lenses and lens adapters 39–43
Extension rings 39–43
Camera mounting brackets 43
Connection cables, external power supplies 38

Principle of TDI Technology

The principle of TDI technology is based on the time-shifted multiple exposure of a moving object. The sensor is composed of 96 line sensors arranged in parallel. At the end of one period of exposure, the accumulated charges in that line sensor are shifted to the next line (see figure, right). During the next exposure period, new charges are acquired, added to the already existing charges and the new sum is again shifted to the next line. Finally, after 96 exposures, the sum of all lines is output as a video signal.

Synchronous transport of a scanned object across the field of the camera actually produces a 96-fold multiple exposure. For each exposure period, the object has moved far enough that the next sensor line is not only ready for exposure but has also already been filled with the accumulated charges from the previous sensor line(s).



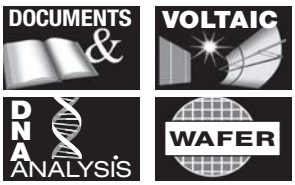
Monochrome TDI line scan cameras from Schäfter+Kirchhoff

Camera	Pixels	Maximum pixel frequency	Maximum line frequency	Active sensor length
SK1024GTDI	1024 x 96	50 MHz	43.4 kHz	13.3 mm
SK2048GTDI	2048 x 96	100 MHz	43.5 kHz	26.6 mm
SK2048U3TDI	2048 x 96	100 MHz	43.4 kHz	26.6 mm
SK4096CTDI-XL	4096 x 96	100 MHz	22.3 kHz	53.2 mm

SK2048U3TDI
Focus adapter FA22-40
Scanning lens
Apo-Rodagon N 4.0/80
Mounting
bracket SK5105

SK4096GTDI-XL
Focus adapter FA26-S45
Macro lens
Apo-Rodagon
D1x 4.0/75
for 1:1 imaging

TDI camera applications



Just 4 applications from 1000s
TDI cameras are especially useful for dimly lit objects

Spectral Sensitivity

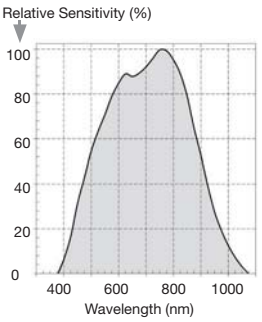


Table 1

Interface	No.	Line scan camera: Order code	Line scan camera: GiGE VISION Order code	Pixels	Line frequency, max.	Video signal	Pixel size	Active length	Anti-Bloom	Integr. Ctrl.	Shading corr.	Threshold mode	Dynamic range (RMS)	Power supply	Camera casing	Lens thread
		1	2	3	4	5	6	7	8	9	10	11	12	13		
Gigabit ETHERNET / GiGE	1	SK1024GTDI-L	SK1024VTDI-L	96 x 1024	43.40 kHz	8/12 Bit	13 x 13 µm	13.30 mm	x	-	x	x	1:2500	+5V, +15V	BG3	M45x0.75
	2	SK2048GTDI-L	SK2048VTDI-L	96 x 2048	43.50 kHz	8/12 Bit	13 x 13 µm	26.60 mm	x	-	x	x	1:2500	+5V, +15V	BG3	M45x0.75
	3	SK4096GTDI-XL	SK4096VTDI-XL	96 x 4096	22.70 kHz	8/12 Bit	13 x 13 µm	53.20 mm	x	-	x	x	1:2500	+5V, +15V	CG5	M72x0.75
USB 3.0	4	SK1024U3TDI		96 x 1024	43.40 kHz	8/12 Bit	13 x 13 µm	13.30 mm	x	-	x	x	1:2500	+5V, +15V	AT2	M40x0.75
	5	SK2048U3TDI		96 x 2048	43.40 kHz	8/12 Bit	13 x 13 µm	26.60 mm	x	-	x	x	1:2500	+5V, +15V	AT2	M40x0.75
CAMERA Link	6	SK1024CTDI		96 x 1024	43.40 kHz	8/12 Bit	13 x 13 µm	13.30 mm	x	-	-	-	1:2500	+5V, +15V	AC2	M40x0.75
	7	SK2048CTDI		96 x 2048	43.40 kHz	2*8 Bit	13 x 13 µm	26.60 mm	x	-	-	-	1:2500	+5V, +15V	AC2	M40x0.75
	8	SK4096CTDI-XL		96 x 4096	22.30 kHz	2*8 Bit	13 x 13 µm	53.20 mm	x	-	-	-	1:2500	+5V, +15V	CC5	M72x0.75
LVDS	9	SK1024ZTDI		96 x 1024	43.40 kHz	8/12 Bit	13 x 13 µm	13.30 mm	x	-	-	-	1:5000	5V, +15V, -15	AL2	M40x0.75
	10	SK2048ZTDI		96 x 2048	26.80 kHz	8 Bit	13 x 13 µm	26.60 mm	x	-	-	-	1:5000	5V, +15V, -15	AL2	M40x0.75
	11	SK4096ZTDI-XL		96 x 4096	14.00 kHz	8 Bit	13 x 13 µm	53.20 mm	x	-	-	-	1:5000	5V, +15V,-15	CL5	M72x0.75

TDI_ZK.indd • Page 30

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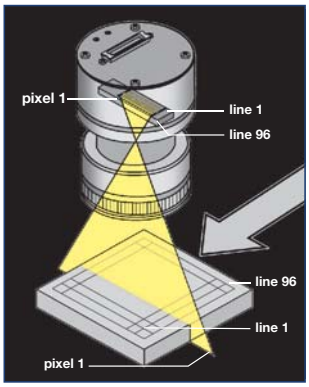
Synchronization of Transport Speed and Line Frequency

To utilize a TDI camera, it is necessary to transport the test object in a designated direction, in relation to the camera (or vice versa), and at a defined velocity (see below). A sharp image of the scanned object can only be achieved when there is perfect synchrony between the transport speed, the exposure time and the magnification.



The optimal transport speed is calculated from the formula:

$$v_O = \frac{w_P \cdot \beta}{t_E}$$

When the transport speed is a given, the line frequency has to be adjusted using:

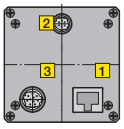
$$f_L = \frac{v_o}{w_P \cdot \beta}$$

where:

v_O = object velocity
w_P = pixel width
β = magnification power
t_E = exposure time

Camera Back View and Connections

GigE Vision / Gigabit Ethernet



1 **Data**
RJ45 connector for Gigabit Ethernet cable CAT6 specification

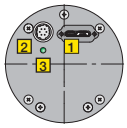
2 **Power**
Hirose Series 10A, male 6-pin, +5 V, 700 mA / +15 V, 50 mA

Pin	Signal	Pin	Signal
1	+15 V	4	+5 V
2	+15 V	5	GND
3	+5 V	6	GND

3 **I/O-Connector**
Hirose Series 10A, male 12-pin

Pin	Signal
1	GND
8	FrameSync
10	LineSync

USB 3.0



1 **Data and power**
USB 3.0 socket, type µB with threaded holes for locking screws

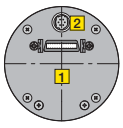
2 **Synchronization**
socket: Hirose series 10A, male 6-pin

Pin	Signal
1	Line Sync B
2	NC
3	Frame Sync
4	NC
5	Line Sync A
6	GND

Line and Frame Sync: TTL levels

3 **Status indicator**
off — no power
red — power on
green — power on, firmware is loaded, camera is ready

Camera Link

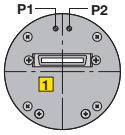


1 **Data**
Mini D Ribbon, female 26-pin

2 **Power**
Hirose Series 10A male 6-pin
+ 5 V, 430 mA / +15 V, 35 mA

Pin	Signal	Pin	Signal
1	+15 V	4	+5 V
2	+15 V	5	GND
3	+5 V	6	GND

LVDS



1 **Data**
Miniature Centronics, male 36-pin

Gain/Offset
P1: Gain single / odd
P2: Offset single/ Gain even

Power supply via line scan grabber SK9193D

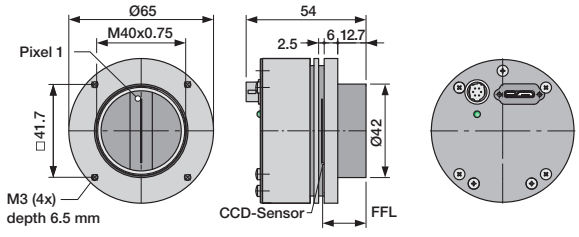
Dimensions

The dimensions are determined by the camera casing according to table 1, column 13. For dimensions and drawings, see pages 58–60. For 4096 x 96 pixel cameras, also see XL-Series section, page 36.

Example: **Round housing, M40x0.75 lens mount**

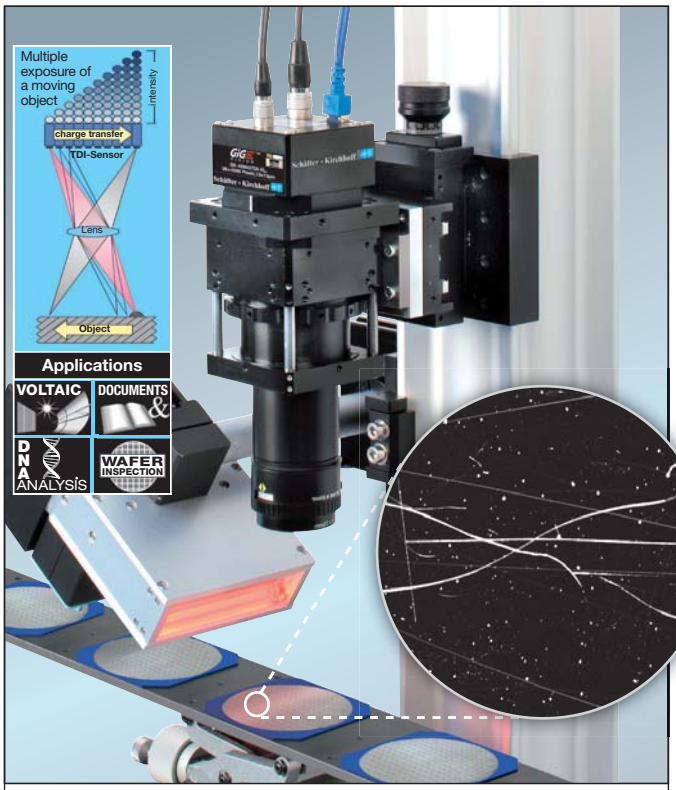
AT2 USB 3.0 interface
AC2 Camera Link interface
AL2 LVDS interface

Seat for bracket: Ø42 mm
Flange focal length: FFL = 19.5 mm



Application

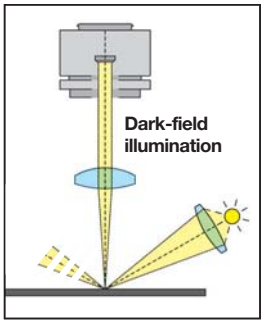
TDI line scan camera: Dark-field illumination of wafer inspection



TDI line scan camera SK4096GTDI-XL with LED/dark-field illumination: inspection of a mirrored surface for dirt and scratches

• Dark-field illumination

In industrial image processing, dark-field illumination is particularly useful for the examination of highly reflecting surfaces. The light beam is directed at the surface of the test object at a low angle of incidence, so that the light is undetected by the camera when reflected from a perfect surface. With an immaculate surface, the scanned object appears completely dark.



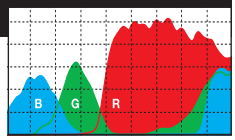
When there are surface irregularities caused by some damage, such as a scratch or a crack, or some contamination, such as dust, lint or grease, then a small part of the incident light is scattered diffusely, captured by the lens and directed onto the sensor. Tiny irregularities can be detected that are even below the resolution limit of the lens. The image may not always be completely in focus anymore, just like viewing a star in the night sky, but the increase in reflected light at the sensor is still detectable.

The process of this type of image acquisition does mean that the image produced by the dark-field illumination of a reflective surface is quite faint. With conventional line scan cameras, substantially longer integration times have to be used in comparison with directed bright-field illumination (see page 52) or for image acquisition from a diffusely reflecting object. For such low signal amplitudes, only low line frequencies and scan velocities are possible.

The highly amplified sensitivity of TDI line scan cameras means that they are particularly suitable for dark-field illumination problems. They also provide much higher measurement and scan velocities for the same absolute degree of object illumination.

• Application fields:
- Surface examination of highly reflective materials, e.g. chips, wafers or mirrored surfaces.
- Highlighting of contours, scratches, cracks, dust particles and dirt.

Line Scan Cameras
from 3 x 1252 to 3 x 10680 pixels



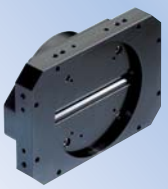
Interfaces:

Interface Gigabit ETHERNET GiGE™

See Table 1, line 3

See Table 1, lines 1–2

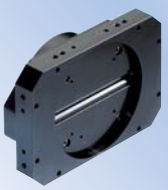
Interface USB 3.0



See Table 1, line 9

See Table 1, lines 4–8

Interface CAMERA Link LVDS



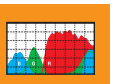
See Table 1, lines 12

See Table 1, lines 10–11, 13-14

Accessories:

	Page
Lenses and lens adapters	39–43
Extension rings	39–43
Camera mounting brackets	43
Connection cables, external power supplies	38

Color Line Scan Cameras
Triple Line and Dual Line RGB Sensor Technology



Color line scan cameras are able to scan the surfaces of moving objects in color. Typical applications are:

- **Surface inspection of wood, ores and minerals**
- **Scanning of books and documents**
- **Quality control of printing**
- **Sorting colored objects, in bulk**

The sensors use red, green and blue (RGB) color-sensitive pixels. With up to 7600 pixels per color, very high optical resolutions are possible. A document in A3 size can be scanned at up to 650 dpi or 39 µm per pixel. For true-color imaging, hardware and software functions for white balance, black level correction and color correction are available. Color calibration using an IT8-target is also possible.

Image acquisition

The acquisition of a color image is achieved by performing a scanning movement of the object or the camera, respectively. The precise synchronization of transport speed and image acquisition ensures the correct aspect ratio and reproducible resolution of the image.

For a given object velocity v_o and field of view FOV, the line frequency f_L can be calculated from the pixel width w and length of the sensor S using:

$$f_L = \frac{v_o \; S}{w \; FOV} \qquad \text{F1}$$

Compliance with conditions of formula F1 is also a prerequisite for accurate color mixing of the RGB colors in the image. Triple line sensors, especially, with their large line spacing produce color convergence errors when F1 is not applicable (Figures 1 and 2).

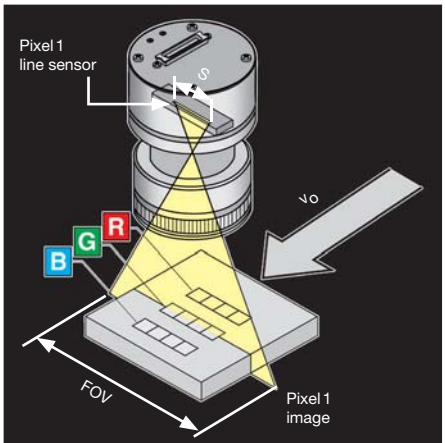


Figure 1. Scanning process: triple line sensor

SK6288GKOC-L
with lens SK1.4/50-40 (with integral focus and aperture adjustment) mounting bracket SK5105

SK6288CKOC
focus adapter FA22R-45, lens Apo-Rodagon N 4.0/80, mounting bracket SK5105-L

SK22800CJRC-XC
focus adapter FA26XC-S55 extension ring ZR55-15 macro lens for 1:3 inspec.x L5.6/105 β-0.33

Table 1

Interface	No.	Line scan camera: Order code	Line scan camera: Order code (GiGE VISION)	Pixels	Line frequency, max.	Video signal	Pixel size	Active length	Anti-Bloom	Integr. Ctrl.	Shading corr.	Threshold mode	Dynamic range (RMS)	Power supply	Camera casing	Lens thread
		1	2	3	4	5	6	7	8	9	10	11	12	13		
Gigabit ETHERNET GiGE™	1	SK6288GKOC-L	SK6288VKOC-L	3 x 2096	9.28 kHz	8/12 Bit	14 x 14 µm	29.30 mm	-	x	x	-	1:2500	+5V, +15V	BG3	M45x0.75
	2	SK12240GKOC-LB	SK12240VKOC-LB	3 x 4080	4.80 kHz	8/12 Bit	10 x 10 µm	40.80 mm	x	x	x	-	1:2500	+5V, +15V	BG3	M45x0.75
	3	SK22368GTOC-LA	SK22368VTOC-LA	3 x 7456	5.13 kHz	3*8 Bit	4.7 x 4.7 µm	35.04 mm	-	-	x	-	1:1000	+5V, +15V	BG3	M45x0.75
	4	SK22800GJRC-XC	SK22800VJRC-XC	3 x 7600	4.95 kHz	3*8 Bit	9.3 x 9.3 µm	70.87 mm	-	-	x	-	1:1000	+5V, +15V	FG7	M72x0.75
USB 3.0	5	SK6288U3KOC		3 x 2096	9.28 kHz	8/12 Bit	14 x 14 µm	29.30 mm	-	x	x	-	1:2500	USB (600 mA)	AT2	M40x0.75
	6	SK8100U3JRC		3 x 2700	2.86 kHz	8/12 Bit	8 x 8 µm	21.60 mm	-	x	x	-	1:2000	USB (500 mA)	AT2	M40x0.75
	7	SK10944U3JRC		3 x 3648	2.14 kHz	8/12 Bit	8 x 8 µm	29.20 mm	-	x	x	-	1:2000	USB (500 mA)	AT2	M40x0.75
	8	SK12240U3KOC-LB		3 x 4080	4.80 kHz	8/12 Bit	10 x 10 µm	40.80 mm	x	x	x	-	1:2500	+5V, +15V	AT3	M45x0.75
	9	SK16080U3JRC-L		3 x 5360	1.47 kHz	8/12 Bit	8 x 8 µm	42.90 mm	-	x	x	-	1:2000	USB (500 mA)	AT3	M45x0.75
	10	SK22500U3NEC-XC		3 x 7504	8.53 kHz	3 * 8 Bit	9.3 x 9.3 µm	69.97 mm	-	-	x	-	1:1000	+5V, +15V	FT7	M72x0.75
CAMERA Link	11	SK6288CKOC		3 x 2096	9.28 kHz	8/12 Bit	14 x 14 µm	29.30 mm	-	x	-	-	1:2500	+5V, +15V	AC2	M40x0.75
	12	SK12240CKOC-LB		3 x 4080	4.80 kHz	8/12 Bit	10 x 10 µm	40.80 mm	x	x	-	-	1:2500	+5V, +15V	AC3	M45x0.75
	13	SK22800CJRC-XC		3 x 7600	6.17 kHz	3*8 Bit	9.3 x 9.3 µm	70.87 mm	-	-	-	-	1:1000	+5V, +15V	FC7	M72x0.75
LVDS	14	SK4096DJRC		2 x 2048	3.50 kHz	8 Bit	12 x 14 µm	28.70 mm	-	-	-	-	1:1000	5V, +15V, -15	AL2	M40x0.75
	15	SK16080DJRC-L		3 x 5360	1.22 kHz	8 Bit	8 x 8 µm	42.90 mm	-	x	-	-	1:1000	5V, +15V, -15	AL3	M45x0.75
Analog	16	SK3072JRC		2 x 1536	1.85 kHz	1/1-4 V	12 x 14 µm	28.70 mm	-	-	-	-	1: 500	5V, +12V, -12	RA2	M40x0.75

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Triple Line Sensors

Line scan cameras are designated according to the number of line sensors as triple line, dual line or single line sensors. **Schäfter+Kirchhoff** offers most camera models with triple line sensors.

Triple line sensors have three separate rows of sensors for the primary colors red (R), green (G) and blue (B). The positions of the R, G and B pixels are defined precisely and triple line sensors exhibit particularly high resolutions. The distance between the line sensors (line spacing) is generally 1, 2, 8 or 9-times the pixel height (h). This spatial distance in the translational direction is automatically corrected during production of the image. For exact color mixing, line synchronous image acquisition according to formular F1 and the direction of transport are particularly important. The color information of a picture with a delay line, Ld, of cycles is incomplete. The line delay Ld is twice the line spacing LS divided by the pixel height h, with both usually measured in microns:

$$Ld = \frac{2\,LS}{h} \qquad \text{F2}$$

Applications in which the transport velocity is not exactly known, such as when imaging bulk products, during free-fall or a photo-finish in a race, should use color line scan cameras with a low line spacing. This has the added advantage that the color convergence errors from the not fully-synchronous signals are smaller and may be neglected.

Color acquisition with Triple Line Sensors

The color line scan camera delivers the red (R), green (G) and blue (B) signals sequentially in a single line signal.

Asynchronous transport during image acquisition results in inappropriate pixel designations and color convergence aberration (Figure 2).

Figure 2. Monochrome font pattern
A Line synchronous object transport
B Asynchronous transport of the object causes color convergence aberration

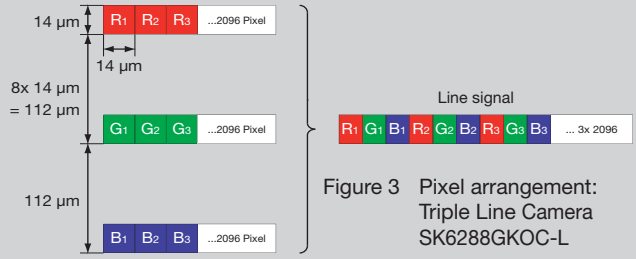
14 µm
R1 R2 R3 ...2096 Pixel
14 µm
8x 14 µm
= 112 µm
G1 G2 G3 ...2096 Pixel
112 µm
B1 B2 B3 ...2096 Pixel
Line signal
R1 G1 B1 R2 G2 B2 R3 G3 B3 ... 3x 2096

Figure 3 Pixel arrangement: Triple Line Camera SK6288GKOC-L

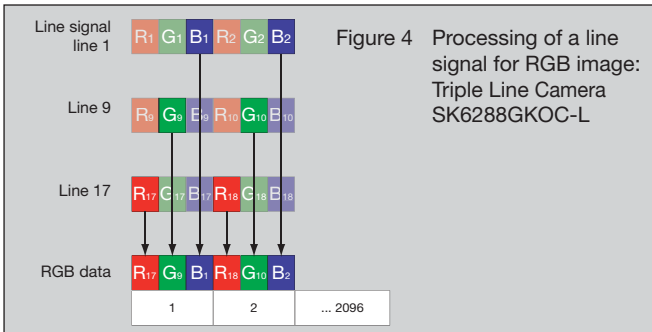

Figure 4 Processing of a line signal for RGB image: Triple Line Camera SK6288GKOC-L

Dual Line Sensor

The Dual Line Sensor has two directly adjoining lines. The first line contains 1024 each of alternating red and blue pixels. The second line contains 2048 green pixels. By caching the red-blue line, the pixels are correctly positioned inside the camera.

Advantages: The color information is included in a single line scan. Minimal color convergence errors with asynchronously moving objects (free-fall or photo-finish camera).

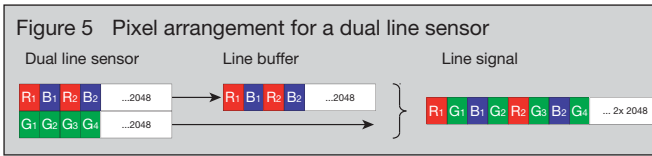

Figure 5 Pixel arrangement for a dual line sensor

Image acquisition with Dual Line Sensors

2D image acquisition data, using a dual line color sensor signal with one line of 2048 green pixels and a second line with 1024 each of alternating red and blue pixels, can be produced by either:

1 using all green pixels once, and the red and blue pixels twice each, so that 2048 image points per line are generated, or

2 combining the red and blue pixel data with the mean of two adjacent green pixels so that 1024 image points per line are generated, which results in a lower resolution image than above.

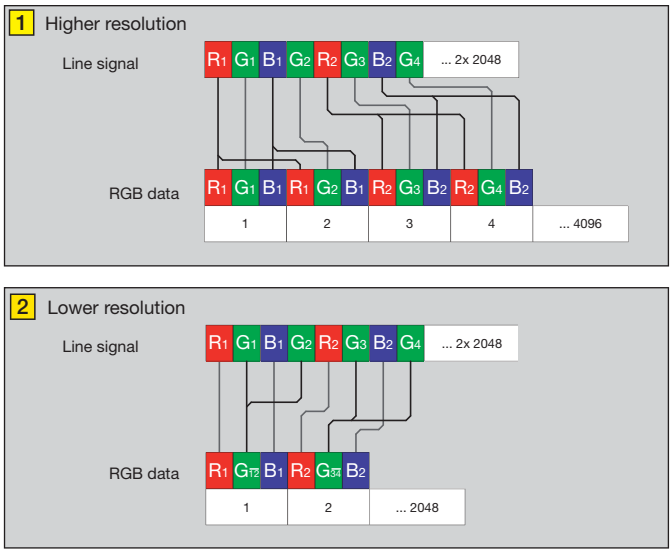

Figure 6. Alternative processing of the line signal for RGB imaging: Dual Line Camera SK4096DJRC

Color management of pictures with color fidelity

Pictures with color fidelity require a color calibration of the line camera. This process requires a scanner system with a translation unit and the scanner software **SKan-G** from **Schäfter+Kirchhoff** (Figure 7).

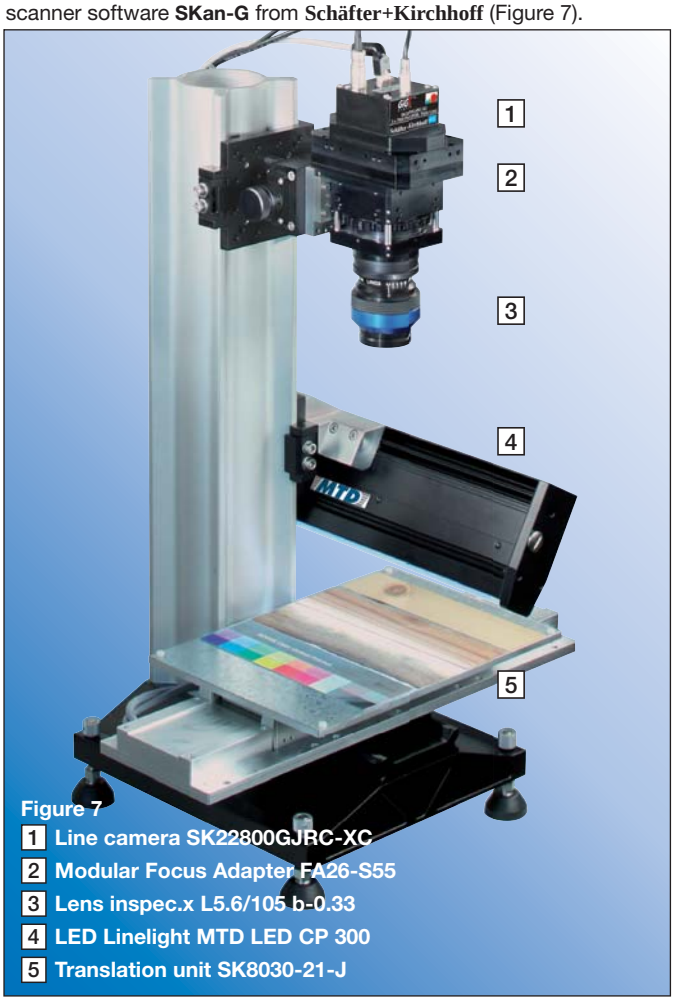

Figure 7
1 Line camera SK22800GJRC-XC
2 Modular Focus Adapter FA26-S55
3 Lens inspec.x L5.6/105 b-0.33
4 LED Linelight MTD LED CP 300
5 Translation unit SK8030-21-J

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White balance

Performing a white balance correction of the individual R, G and B components of the line signal results in the intensities of the three basic colors produced using a white template (sheet of paper) being matched over the entire sensor length.

First, a coarse adjustment of the RGB signals in the oscilloscope display of the line signal is performed using the Gain Controller in the Gain/ Offset dialog. The red, green and blue curves are now coincident, A.

Second, the curved line signals can now be flattened, which counteracts any manifestations of lens vignetting, inhomogeneous illumination and non-uniformity of the sensor. A scan of a white template over a defined distance is performed to produce a 2D image. The software calculates a reference curve to correct for variations in brightness. The resulting look-up table is stored in the flash-memory of the camera and, thereafter, the correction is automatically applied within the camera. A new scan of the white template reveals a homogenous intensity distribution over the entire image. During this process, the software also corrects for template irregularities and dust flecks automatically.

Color correction

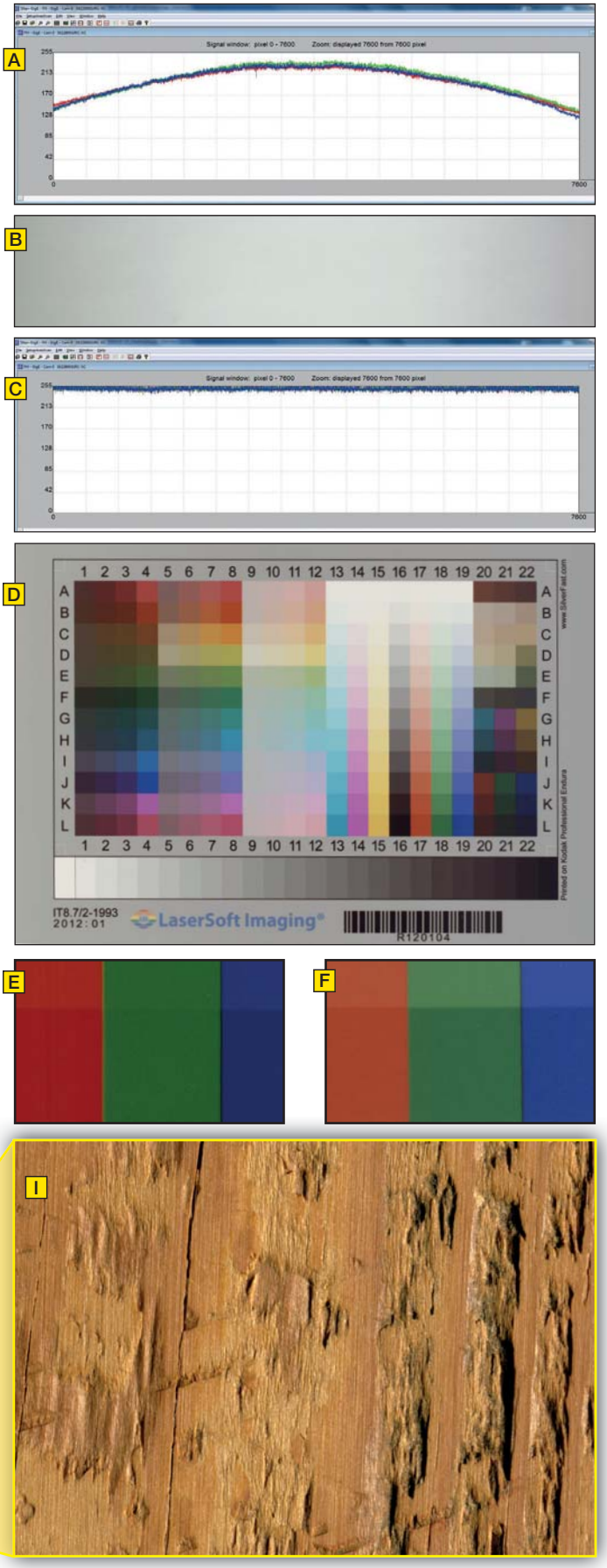
A white balance correction is not a guarantee of color fidelity for all colors in a colored template. Disturbances can arise from the spectral properties of the illumination unit or of the sensor, as well as from the whiteness properties of the template used for the white balance.

For effective color reproduction by the entire scanner, a standardized color calibration is necessary using an IT8-Target of defined size and color palette. The IT8-Target is imaged by the scanner and the software calculates an ICC-Profile on the basis of defined reference values. Subsequent scans can use this profile to produce images with reliable color fidelity.

The **SKan-G** software produces lossless pictures with an embedded ICC-Profile for storage in .png and other formats.

Wood surface inspection with the color line camera SK22800GJRC-XC

Pixel:	3x 7 600 (RGB), 9.3 x 9.3 µm²,	Sensor length: 70.68 mm
Line frequency:	max. 4.93 kHz,	Interface: Gigabit Ethernet
Measuring range:	**320 mm x 2 500 mm**	
Resolution:	600 dpi, 42 µm/pixel	
Picture size:	7 600 x 60 000 pixel (24-bit), in the PC RAM	
Storage format:	bmp, png with embedded ICC-Profile	



Caption:

A Line signal after RGB signal adjustment using a white template
B Area scan for determination of the reference signal for white balance
C Line signal after white balance
D Area scan of an IT8-Target with active white balance
E Zoomed section around the field L18, uncorrected
F Zoomed section around the field L18, corrected using ICC-Profile
G Line signal of the brown wooden surface (small amount of blue)
H Area scan of the wooden surface before color correction
I Zoomed section of H after color correction

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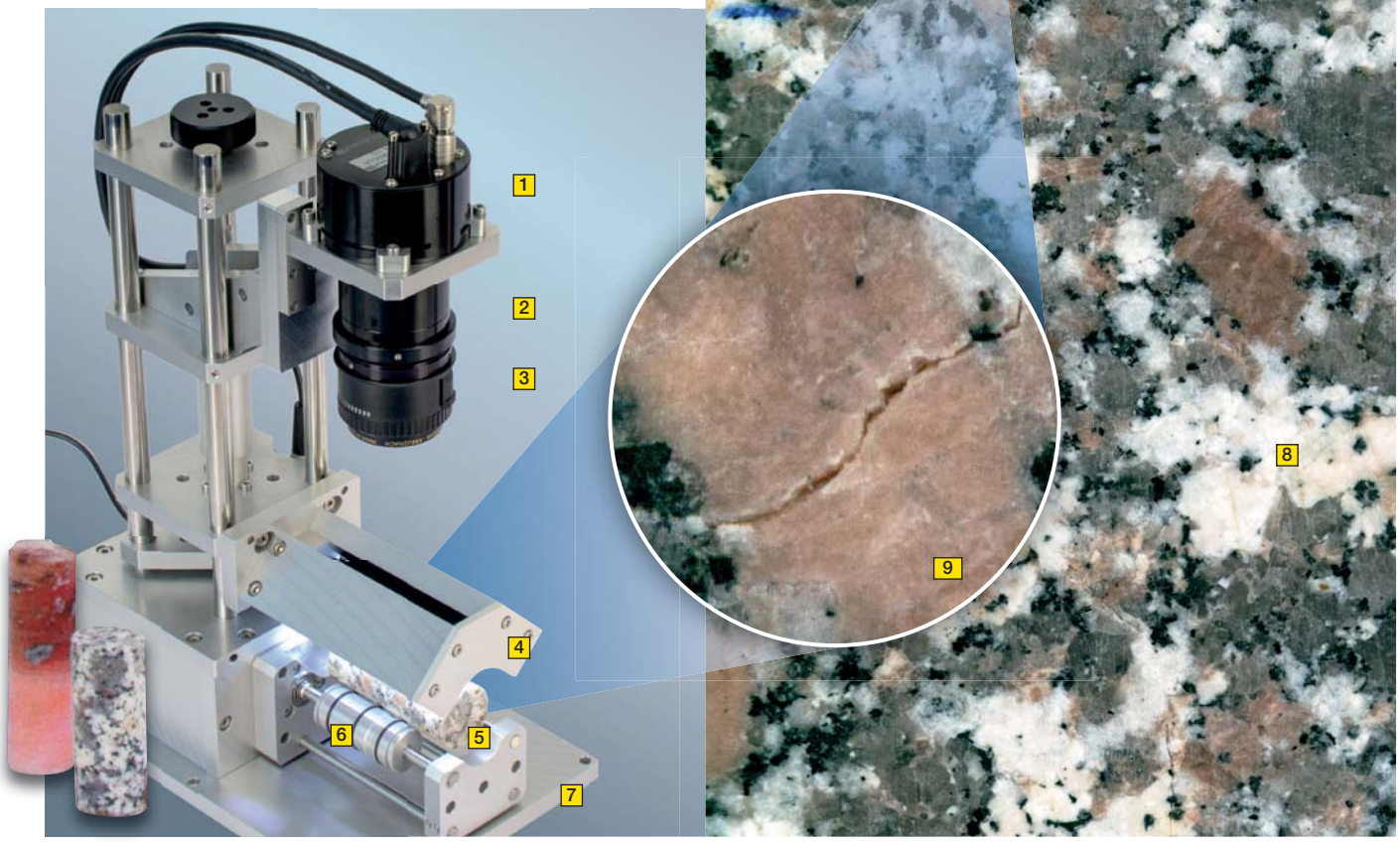
Specialized application:
Plug Scanner SK-2096-USB3-Color
for automated bore plug inspection

Color line scan camera SK6288U3KOC, 3x 2096 pixel (RGB)

- For object lenght 50–75 mm
- Optical resolution 1050–700 dpi
- Object diameter of **25–50 mm**



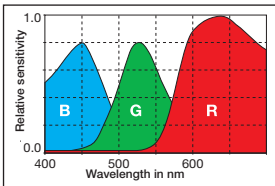
The bore plug scanner SK-2096-USB3-Color is a fully mobile surface-scanning macroscope that was specially developed by **Schäfter+Kirchhoff** for the investigation of smooth cylindrical objects, such as bore plugs.

Features:

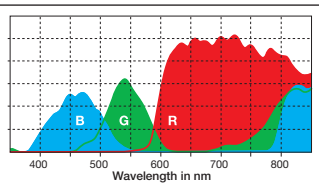
- Rapid and precise exchange of test objects by using two rotating supports
- Simple adjustment of focus for objects with different diameters
- NEW The new USB 3.0 interface enables the scanner to be transported and used almost anywhere
- A surface scan by simply pressing a switch or clicking a mouse button
- Automatic white balance
- One-click zooming for 1:1 depictions
- Printing and saving of complete or zoomed sections

1 Color line scan camera SK6288U3KOC with USB 3.0-interface
2 Macro lens
3 Lens protective casing
4 Illumination (2 linear white LEDs)
5 Bore plug object Ø1.5", length 3"
6 Driven rotator
7 Stand and housing for motor and electronics
8 Generated surface of bore plug
9 Zoom detail of bore plug surface

Color line scan cameras - spectral responsivity



Spectral responsivity of triple line cameras of the SK...JRC series



Spectral responsivity of triple line cameras of the SK6288... series

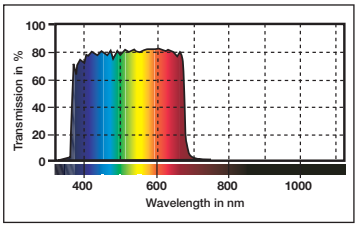
UV-IR filter type 486

The UV-IR filter blocks unwanted UV and IR radiation, leading to a contrast increase

FBP - UVIR - 27 Order Code

27 = M27 x 0.5
40 = M40.5 x 0.5
43 = M43 x 0.75
52 = M52 x 0.75
58 = M58 x 0.75
62 = M62 x 0.75
72 = M72 x 0.75
86 = M86 x 1.00

Filter thread



Color line scan cameras: connectors and dimensions

Interface	Connectors page 38 and ...	Dimensions pages 58–60 and ...
GigE	18	18
USB 3.0	21	23
CameraLink	25	24
Analog	28	28

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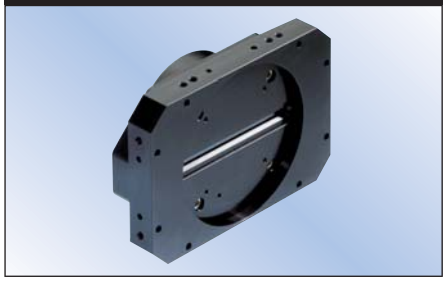
Line Scan Cameras

7500 pixel, 8160 pixel
96 x 4096 pixel
3x4080 pixel, 3x7600 pixel



Large Line Sensors XL / XB / XC

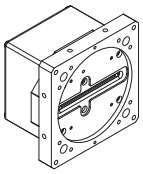
for active sensor lengths up to 71 mm

The line scan cameras XL/XB/XC have an adapter flange for attaching one of the **Schäfter+Kirchhoff** high precision focus adapters **FA26-S45** or **FA26-S55**. These adapters with their stable linear tracking rods provide a precise focussing travel that can be locked in the final position.
By using macro or scan lenses, an extremely robust optomechanical unit can be produced that is highly suited to the most demanding of industrial environments.

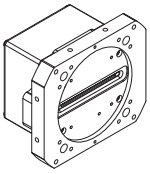
The focus adapter FA26-S45 (attachment thread M45x0.75) is used in combination with the adapter M39-45 for scan and macro lenses with the attachment thread M39x1/26".
The variant FA26-S55 (thread M55x0.75) in combination with the AC46-55 adaptor is applicable for AC46-lenses.
Alternative accessories include extension rings, lens-specific adapters and V-groove adapters, with the latter enabling the lens to be mounted at any angle of rotation.

Camera casing variants for large sensors:

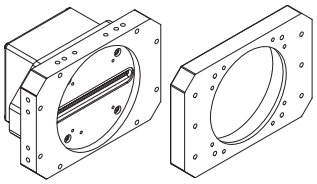
XL Sensor length up to 53 mm



XB Sensor length up to 53 mm



XC Sensor length up to 71 mm



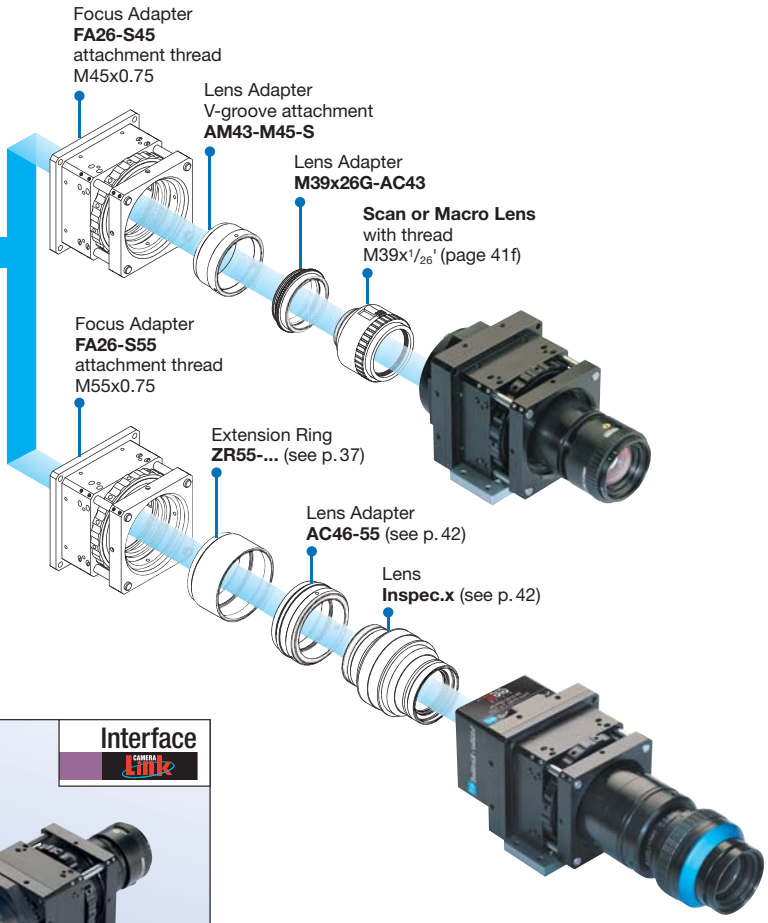


Table 1

Interface		Line scan camera: Order code	Line scan camera: GiGE Vision Order code	Pixels	Line frequency, max.	Video signal	Pixel size	Active length	Anti-Bloom	Integr. Ctrl.	Shading corr.	Threshold mode	Dynamic range (RMS)	Power supply	Camera casing	Lens thread
				1	2	3	4	5	6	7	8	9	10	11	12	13
Gigabit ETHERNET	1	SK8160GKO-XL	SK8160VKO-XL	8160	11.90 kHz	8/12 Bit	5 x 5 µm	40.80 mm	x	x	x	x	1:2500	+5V, +15V	CG5	M72x0.75
Camera Link	2	SK8160CKO-XL		8160	11.90 kHz	8/12 Bit	5 x 5 µm	40.80 mm	x	x	-	-	1:2500	+5V, +15V	CC5	M72x0.75
Gigabit ETHERNET	3	SK7500GTF-XB	SK7500VTF-XB	7500	8.26 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	x	x	1:1000	+5V, +15V	EG5	M72x0.75
USB 3.0	4	SK7500U3TF-XB		7500	10.10 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	x	-	1:1000	+5V, +15V	ET5	M72x0.75
Camera Link	5	SK7500CTF-XB		7500	10.10 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	x	-	1:1000	+5V, +15V	EC5	M72x0.75
Gigabit ETHERNET	6	SK7500GTO-XL	SK7500VTO-XL	7500	5.20 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	x	x	1: 750	+5V, +15V	CG5	M72x0.75
USB 3.0	7	SK7500U3TO-XL		7500	5.20 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	x	x	1:1000	USB (600 mA)	CT5	M72x0.75
Camera Link	8	SK7500CTO-XL		7500	5.20 kHz	8/12 Bit	7 x 7 µm	52.50 mm	-	-	-	-	1: 750	+5V, +15V	CC5	M72x0.75
Camera Link	9	SK4096CTDI-XL		96 x 4096	22.30 kHz	2*8 Bit	13 x 13 µm	53.20 mm	x	-	-	-	1:2500	+5V, +15V	CC5	M72x0.75
Gigabit ETHERNET	10	SK4096GTDI-XL	SK4096VTDI-XL	96 x 4096	22.70 kHz	8/12 Bit	13 x 13 µm	53.20 mm	x	-	x	x	1:2500	+5V, +15V	CG5	M72x0.75
Gigabit ETHERNET	11	SK12240GKOC-XL	SK12240VKOC-XL	3 x 4080	4.80 kHz	8/12 Bit	10 x 10 µm	40.80 mm	x	x	x	-	1:2500	+5V, +15V	CG5	M72x0.75
Camera Link	12	SK12240CKOC-XL		3 x 4080	4.80 kHz	8/12 Bit	10 x 10 µm	40.80 mm	x	x	-	-	1:2500	+5V, +15V	CC5	M72x0.75
USB 3.0	13	SK22500U3NEC-XC		3 x 7504	8.53 kHz	3 * 8 Bit	9.3 x 9.3 µm	69.97 mm	-	-	x	-	1:1000	+5V, +15V	FT7	M72x0.75
Gigabit ETHERNET	14	SK22800GJRC-XC	SK22800VJRC-XC	3 x 7600	4.95 kHz	3*8 Bit	9.3 x 9.3 µm	70.87 mm	-	-	x	-	1:1000	+5V, +15V	FG7	M72x0.75
Camera Link	15	SK22800CJRC-XC		3 x 7600	6.17 kHz	3*8 Bit	9.3 x 9.3 µm	70.87 mm	-	-	-	-	1:1000	+5V, +15V	FC7	M72x0.75

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Accessories

Focus Adapter FA26-S45 with Thread M45x0.75

High-precision adapter with linear tracking rods for precise travel of the focussing encasement, with locking of the focus position

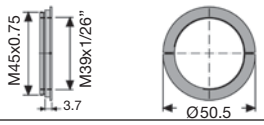
Optomechanical component as housing for line scan cameras of the family -XL

- Focussing range 30 mm, 1 turn of the focussing ring corresponds to 10 mm
- Screws for locking the focus
- **Thread M45x0.75 for extension rings and adapters (adapter M45-39 for lens thread M39x1/26" or adapter with V-groove for a rotatable lens)**

Accessories for FA26-S45: Extension Rings and Lens Adapters

Lens Adapter M45x0.75 to M39x1/26" (Leica)

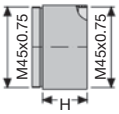
M39-45 Order Code
M39x1/26" – M45x0.75
The Adapter M39-45 adds 3.7 mm to the optical tube length



Extension Rings ZR-L... M45x0.75

ZR-L 25 Order Code
15 = Length 15 mm
25 = Length 25 mm
60 = Length 60 mm
87 = Length 87 mm

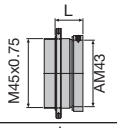
Thread M45x0.75 on both sides (internal/ external)



Lens Adapter M45x0.75 to AM43

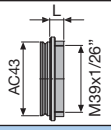
Order Code
AM43-M45 (length L=35 mm)
AM43-M45-S (length L=20 mm)

The AM43-M45 accepts the lens adapter with V-groove AC43

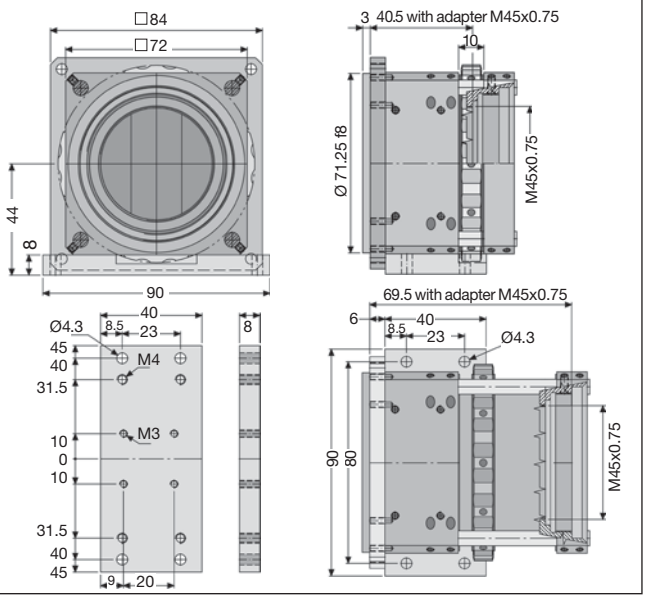


Lens Adapter V-Groove AC43 to M39x1/26" (Leica)

Order Code
M39xG26-AC43 (length L=8.2 mm)
M39x26G-AC43-S (length L=1.5 mm)



Dimensions - Focus Adapter FA26-S45



Focus Adapter FA26-S55 with Thread M55x0.75

High-precision adapter with linear tracking rods for precise travel of the focussing encasement, with locking of the focus position

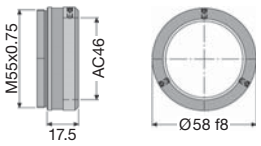
Optomechanical component as housing for line scan cameras of the family -XL

- Focussing range 30 mm, 1 turn of the focussing ring corresponds to 10 mm
- Screws for locking of the focus
- **Thread M55x0.75 for extension rings and adapters (adapter AC46-55 for lens thread M55x1/26")**

Accessories for FA26-S55: Extension Rings and Lens Adapters

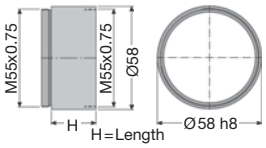
Lens Adapter M55x0.75 to AM46

AC46-55 Order Code
The Adapter AC46-55 adds 17.5 mm to the optical tube length.
It accepts the AC46 V-groove of the Inspec.x macro lenses.

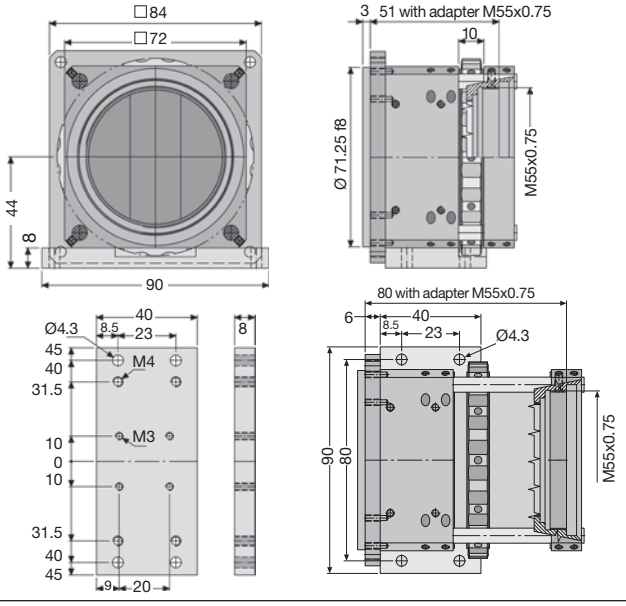


Extension Rings ZR55-... M55x0.75

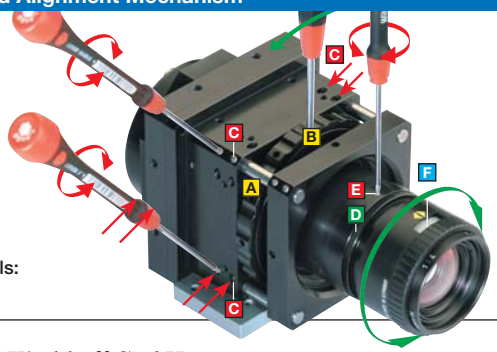
ZR55-... Order Code
15 = Length 15 mm
25 = Length 25 mm
60 = Length 60 mm



Dimensions - Focus Adapter FA26-S55



Focussing and Alignment Mechanism



Assembly and adjustment tools:
see page 60

Lens focussing, azimuth alignment and locking

- A Linear tracking rods
- B Focussing ring, range ±15 mm (1 turn = 10 mm)
- C Screws for locking the focussing encasement, Allen key 1.5
- D V-groove adapter M39x26G-AC43 for free alignment of the lens angle of rotation, lens thread M39x1/26"
- F Aperture stop setting
- E Screw for locking the lens housing, hex Allen key 1.5

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